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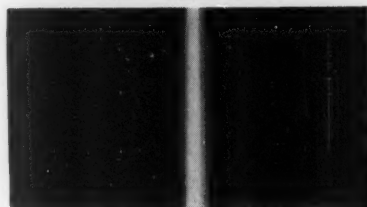
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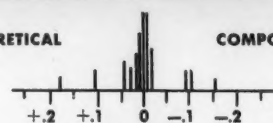
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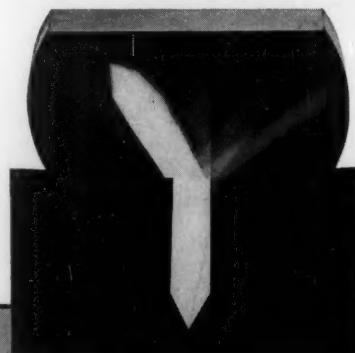
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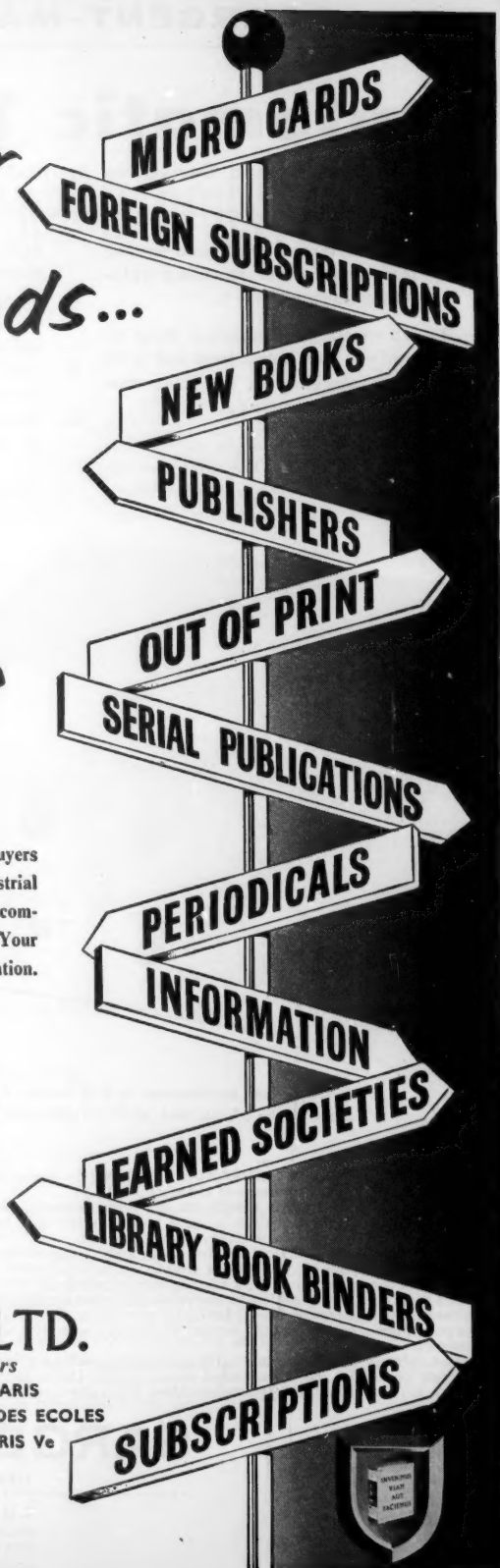
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## Babel Resolved

The babel of languages hampers international communication in science as in other fields of human knowledge. For the first time in human history, an international language has been fashioned that can be read at sight by all who can read any Western European language.

This language is Interlingua. Interlingua is a planned, natural, auxiliary language. It is neither constructed nor synthetic. It is based on the words and grammar (simplified and regularized) of the predominant European languages; it can be considered a sort of basic, average language (primarily for reading), common to most of the reading world.

Interlingua is in use. It has made remarkable progress in the 5 years since its simple rules were formulated and put into practice. The article on page 64 is written in Interlingua so that anyone can demonstrate to himself how easy it is to read. Experience shows that Interlingua can be read without study or preparation by German, French, Italian, Anglo-Saxon, and South American people, as well as by Japanese, Russian, and other people who have been exposed to occidental linguistic patterns.

More than a quarter century of linguistic research in the laboratories of the International Auxiliary Language Association, supported largely by the late Ambassador and Mrs. Dave Hennen Morris, produced Interlingua. It was then put into use through cooperation between editors of journals and international conferences and a new division of Science Service. Since 1953 it has come into use for publication of summaries in 17 medical journals and has served as the only secondary language in the programs of seven international medical congresses. This practical demonstration, largely in the medical field, paves the way for other utilizations.

Future applications will be facilitated, to the extent that resources are available, by the Interlingua Division of Science Service (80 E. 11 St., New York City), the chief of which is Alexander Gode, who was primarily responsible for the evolution and formulation of Interlingua.

Written Interlingua is a running mate to simultaneous interpretation in international conferences. By the simple expedient of producing one additional written version (in Interlingua) of program, information, and abstracts of papers, the whole proceedings may be made available to all.

If Interlingua summaries are appended to journal articles, the journal may be made readable throughout the intellectual world.

Interlingua differs from earlier auxiliary languages, such as Esperanto, in that it does not offer a new system of communication that needs to be studied and learned. No attempt is being made either to organize those who are interested in the use of Interlingua or to teach it to large numbers of people. If it is used, it is successful. Some trials in high schools, however, indicate that Interlingua can be used as an introduction to language study.

Interlingua's application to science is a pilot operation. It should also prove to be of service in other fields in which international communication is necessary.

WATSON DAVIS, *Director, Science Service*



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## *How UHF radio got seven-league boots*

THE huge antenna systems which project ultra-high frequency radio communications beyond the horizon began when a Bell Telephone Laboratories engineer became intrigued with a strange phenomenon. Although these radio waves were supposed to be useful only over line-of-sight distances, the waves displayed a mysterious tendency to take off in a giant stride to antennas beyond the horizon.

This phenomenon had been studied both here and abroad, but no practical use was seen until the engineer became interested and thoroughly sifted the experimental data. He came up with the stimulating conclusion that over-the-horizon transmission is far stronger and much more dependable than was generally supposed. Further he predicted that it could be utilized to supply dependable broadband communications. He and his associates at Bell Laboratories confirmed the prediction experimentally, then drew up requirements for the first over-the-horizon UHF transmission system.

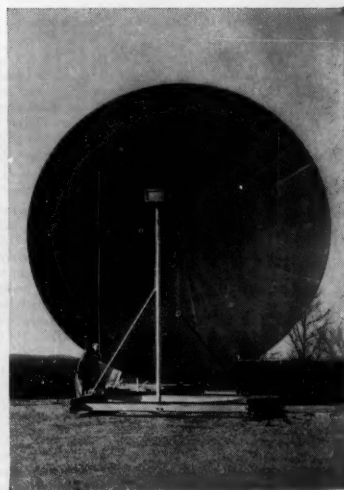
This pioneer work at Bell Telephone Laboratories has greatly increased the usefulness of UHF communications. For example, over-the-horizon transmission now provides critically important communications between remote military outposts in the Arctic and in the far north.

For the Bell System it can provide important new links for telephone conversations and television.



Contributions in the field of over-the-horizon ultra-high frequency radio transmission.

Kenneth Bullington, B.S.E.E., University of New Mexico; M.S., Massachusetts Institute of Technology; recipient of the 1956 Morris Liebmann Memorial Prize and the 1956 Stuart Ballantine Medal for his contri-



Experimental antenna used in early over-the-horizon UHF radio transmission research. Research extended transmission from 30 miles line-of-sight to 200 miles.

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## Biological Activity of Free Radicals

Barry Commoner, John J. Heise, Barbara B. Lippincott,  
Richard E. Norberg, Janet V. Passonneau, Jonathan Townsend

Electron transport, the physical process that governs the chemistry of biological oxidations is, as yet, poorly understood. Most of the known reactants and products in metabolic oxidation-reduction systems are ordinary molecules in which all electrons necessarily occur in pairs. It might be expected, then, that electron transfers among these molecules would also occur in pairs. However, in several important instances, the chain of electron transport also includes metallo-organic substances, such as cytochrome, in which oxidation-reduction involves only a single electron. To account for the necessary linkage between such one-electron steps and apparent two-electron steps, Michaelis proposed the hypothesis "that all oxidations of organic molecules, although they are bivalent, proceed in two successive univalent steps, the intermediate state being a free radical" (1). Unlike ordinary molecules, a free radical contains an unpaired electron.

A second unresolved issue is the physical relationship between electron donor and electron acceptor. In ordinary solution, electron transfer occurs during collision between the donor and acceptor molecules. In biological systems, however, the reacting molecules are bound to the large protein component of the enzyme. It is then possible that the donor and acceptor are not in direct contact and that the necessary electron transfer occurs by a type of conduction through the substance of the intervening protein. This notion was first proposed in Szent-Gyorgyi's continuum theory (2) and, despite subsequent discussion and some experiment, it is as yet neither proved nor disproved. Such a system is analogous to a semiconductor, as first pointed out by Szent-Gyorgyi (3), in

which electron transfer is a univalent process. During this process, a semiconductor would contain unpaired electrons.

These considerations imply that free radicals are intermediates in metabolic oxidation-reductions. Equally indirect evidence suggests that carcinogenesis by chemical agents may result from their metabolic conversion, within the cell, into unusually stable free radicals (4). This view is supported by the fact that physical carcinogenic agents—that is, ionizing radiation and ultraviolet light—induce the formation of free radicals *in vitro* (5). Similar theoretical considerations have led to suggestions that free radicals and components of the semiconductor type participate in photosynthesis (3, 6).

Thus, there have been inferences, but until now no firm proof, that free radicals and similar components that contain unpaired electrons are involved in a number of fundamental biological processes and that free radical mechanisms may be a ubiquitous attribute of the chemistry of living substance. Experimental evidence might be expected to elucidate these processes and the general mechanism of biological electron transport.

### Electron Spin Resonance

A direct experimental approach to these questions was made possible by the discovery by Zavoisky in 1945 (7) of the electron-spin-resonance (ESR) absorption and by the subsequent development of ESR spectrometers capable of revealing the presence of unpaired electrons due to the absorption of incident microwave energy under the influence of an

appropriate external magnetic field. The spectrometer records the absorption of incident microwave energy of a fixed frequency as the strength of the magnetic field is varied. Electron spin resonance arises from the interaction of the inherent magnetic moment of an unpaired electron with the external magnetic field. The absorption of microwave energy of a given frequency ( $\nu$ ), which represents the ESR signal, occurs at a particular value of the external magnetic field ( $H$ ), the relationship between the two factors being determined by the equation

$$\nu = \text{a constant} \times g \times H$$

In this equation, variations in the term  $g$  reflect the interactions of the electron's magnetic moment with the electron's environment. For organic free radicals,  $g$  varies about the free-electron value of 2.0023, in a narrow range of about 2.0010 to 2.0070 (8). A given free radical exhibits a characteristic value of  $g$  within this range.

A free radical may be characterized as well by the width of the ESR absorption, which is generally expressed as the line width (in gauss) at one-half the maximum absorption. Finally, certain free radicals may be characterized by the detailed structure of their electron spin resonance. This structure arises from the fact that certain atomic nuclei possess a magnetic moment which may interact with the magnetic moment of a neighboring unpaired electron. The otherwise simple absorption of the electron then becomes resolved into multiple lines or hyperfine structure. For a given free radical, such hyperfine splitting is characteristic, and sometimes unique, with respect to relative peak heights and spacing along the magnetic field. The characteristics of the ESR line may also serve to distinguish among the three generic types of components that contain unpaired electrons—that is, free radicals, semiconductors, and paramagnetic ions of the transition elements.

This technique was first applied to biological materials by Commoner, Townsend, and Pake (9). Although the spectrometer then available precluded the use of wet (and therefore biologi-

Dr. Commoner, Mr. Heise, Mrs. Lippincott, and Dr. Passonneau are on the staff of the Henry Shaw School of Botany, Washington University, St. Louis, Mo. Dr. Norberg and Dr. Townsend are on the staff of the department of physics, Washington University.



cally active) samples, it was shown that electron spin resonance occurs in a wide variety of lyophilized tissues and that the magnitude of the signal is related to the tissue's relative metabolic rate. Since direct proof that free radicals are metabolic intermediates requires evidence that they occur during the course of biochemical processes, a new highly sensitive spectrometer for samples containing about 0.1 milliliter of liquid water has now been constructed (for a brief description, see 10). With this apparatus, it has become possible to study various active biochemical and biological systems. The present article (11) summarizes the results of this work, which show that free radicals and probably components of the semiconductor type are active constituents of certain biological oxidation-reduction systems and of living cells.

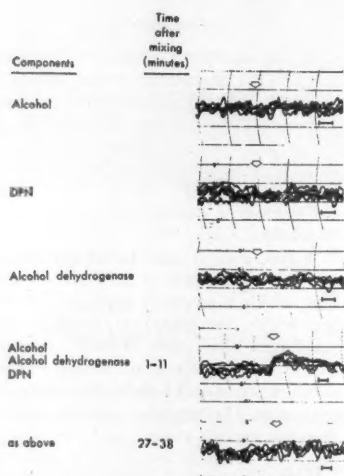


Fig. 1. Electron spin resonance (ESR) from the separate components of the alcohol dehydrogenase system, and from the complete system: 0.06 ml of 50-percent alcohol, 30 mg of oxidized diphosphopyridine nucleotide (DPN<sup>+</sup>), 50 mg of alcohol dehydrogenase (Sigma), and 0.12 ml of Tris buffer at pH 8.0. The magnetic field increases toward the right along the abscissa. The bars at the right of each record represent a 10-gauss increment. The arrows mark the position of the electron spin resonance of a standard free radical, peroxyamine disulfonate ion, for which  $g = 2.005$ . The ordinate represents the rate of change, with respect to field strength of microwave energy (9000 Mc/sec) absorbed by the sample, as the strength of the magnetic field is varied. The records shown represent superimposed tracings of sequential runs. The electron spin resonance shown by the complete system, which is indicated by the deflection from the base line, occurs at a magnetic field which corresponds to a  $g$  value of about 2.006. Ambient temperature: about 35°C.

## Simple Enzyme Systems

The simplest biochemical process in which a free radical intermediate might occur is an enzyme-mediated, coupled oxidation-reduction of two substances—for example, substrate-dehydrogenase-coenzyme systems. In this reaction, two electrons are transferred from the dehydrogenase substrate to the coenzyme. If the process takes place in two successive single-electron steps, free radical intermediates capable of exhibiting electron spin resonance should occur. Since such free radicals are frequently rather unstable substances, one must anticipate that the steady-state concentrations may be very small.

To attain a maximal concentration, the components are placed in the ESR spectrometer cell in the dry form, and about 0.1 milliliter of the appropriate buffer is then mixed with these materials. The cell is inserted into the resonance cavity as quickly as possible, and rapid sweeps are made of the region of the external magnetic field in which electron spin resonance due to free radicals is expected to occur.

Results obtained with the alcohol dehydrogenase system are presented in Figs. 1 and 2. No electron spin resonance is obtained from the dehydrogenase, alcohol, or oxidized diphosphopyridine nucleotide (DPN<sup>+</sup>) when these are examined separately. However, within 1 minute after all three components are mixed, a discernible ESR signal appears which persists for about 10 minutes and then gradually disappears. After 27 minutes, the signal is no longer detectable.

Alcohol dehydrogenase also catalyzes the reverse process in which reduced diphosphopyridine nucleotide (DPNH) is oxidized and acetaldehyde is reduced. Results obtained with this reaction are shown in Fig. 2. The separate components yield no ESR signal. The complete system exhibits an electron spin resonance during the first 15 minutes after the reaction starts, and the signal rapidly disappears thereafter.

The observed signals occur at a magnetic field which represents a value for  $g$  of about 2.006; this is within the range typical of free radicals. The electron spin resonances described in Figs. 1 and 2 represent (on the basis of comparison with a standard amount of a known free radical) roughly  $10^{-11}$  mole of unpaired electrons. This may be compared with the amount of diphosphopyridine nucleotide (DPN) present, which is  $10^{-6}$  mole, or  $10^6$  times the number of unpaired electrons.

Thus, the signal observed in the alcohol dehydrogenase system exhibits a  $g$  value which is consistent with an electron spin resonance arising from an or-

ganic free radical. The electron spin resonance depends on the activity of the complete system, appears as a transient phenomenon during the course of either the "forward" or "reverse" process, and reflects an exceedingly low steady-state concentration of unpaired electrons. In all these respects, the observed electron spin resonance conforms with the expectation, based on Michaelis' hypothesis, that free radical intermediates are formed during the activity of the alcohol dehydrogenase system. Similar results have been obtained with two other dehydrogenase systems: (i) lactic acid dehydrogenase, lactic acid, and diphosphopyridine nucleotide; and (ii) glucose-6-phosphate, glucose-6-phosphate dehydrogenase, and triphosphopyridine nucleotide (TPN).

Comparable experiments have been carried out with a more complex enzyme system: reduced diphosphopyridine nucleotide, cytochrome reductase, cytochrome *c*, cytochrome oxidase, and  $O_2$ , in which electrons are transferred from component to component in the order given. The terminal electron donor, reduced diphosphopyridine nucleotide, is supplied in excess, so that the over-all activity of the system is regulated by the concentration of the ultimate electron acceptor and the turnover rates of the intervening cyclic oxidation-reduction steps.

The results are shown in Figs. 3A and 3B. When reduced diphosphopyridine nucleotide and cytochrome reductase are mixed, a transient electron spin resonance appears, which disappears within 10 minutes. When the system contains reduced diphosphopyridine nucleotide, cytochrome reductase, and cytochrome

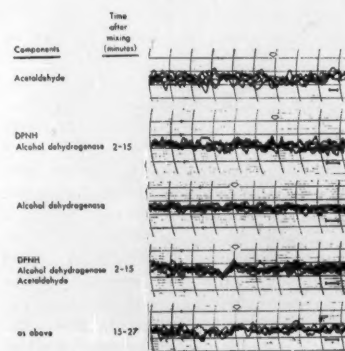


Fig. 2. Electron spin resonance from the alcohol dehydrogenase system, with reduced diphosphopyridine nucleotide (DPNH) and acetaldehyde as substrates. Details are the same as those described in Fig. 1, except that the system contained 30 mg of reduced diphosphopyridine nucleotide and 0.1 ml of acetaldehyde.

*c*, a larger electron spin resonance appears immediately after mixing. The signal slowly decreases in amplitude, although it is still evident 1½ hours later. If cytochrome oxidase is then added, an immediate enhancement of the ESR signal occurs, which persists relatively undiminished for at least 1½ hours. Control runs, carried out with each of the components separately (See Fig. 3B) show no electron spin resonance with the possible exception of a very weak signal in the case of reduced diphosphopyridine nucleotide. It is probable that this electron spin resonance reflects the slow, spontaneous reoxidation of reduced diphosphopyridine nucleotide by oxygen. An even weaker signal of doubtful significance may be present in the spectrometer run made with the reductase alone.

The activity of this system is wholly dependent on the reductase, since electron transfer between reduced diphosphopyridine nucleotide and cytochrome *c* does not occur. It is significant, therefore, that when atabrine, a competitive inhibitor of cytochrome reductase (12), is added to an active system, the electron spin resonance abruptly disappears (see Fig. 3B).

The electron spin resonances of the cytochrome reductase system exhibit somewhat variable values of *g*. For the electron spin resonances first observed after reduced diphosphopyridine nucleotide, reductase, and cytochrome *c* are mixed, *g* is about 2.006. In longer runs, *g* appears to drift toward higher values. The shift suggests that variable concentrations of two or more types of free radical occur, or that the changing composition of the system influences the character of a single free radical.

The results conform to the expectation that free radical intermediates occur during the activity of the cytochrome reductase system. The small, transient electron spin resonance observed when reduced diphosphopyridine nucleotide and cytochrome reductase are mixed is evidence that short-lived free radical intermediates are formed during the limited transfer of electrons from reduced diphosphopyridine nucleotide to the flavin moiety of cytochrome reductase. When cytochrome *c* is also present, the electron spin resonance is more intense and more sustained in time. This is to be expected from the fact that cytochrome *c* serves to reoxidize the flavin, thereby augmenting the rate and duration of the cyclic oxidation-reduction. As the cytochrome *c*, which is the terminal electron acceptor in this system, becomes reduced, the transfer rate and the amplitude of electron spin resonance diminish. The enhanced electron spin resonance owing to the subsequent addi-

tion of cytochrome oxidase is similarly consistent with the oxidase's biochemical activity—that is, the regeneration of oxidized cytochrome *c* and the resulting enhancement of the rate of the over-all process. Finally, the effect of atabrine is evidence that the electron spin resonance exhibited by the system is a specific function of the enzymatic activity of cytochrome reductase. Thus, the re-

sults of experiments with electron spin resonance conform with expectations based on the biochemical activities of the cytochrome reductase system.

The available data do not yet permit identification of the specific free radicals responsible for the observed electron spin resonance. The occurrence of an electron spin resonance in the alcohol dehydrogenase system suggests that diphosphopyridine nucleotide forms a free radical intermediate. There is spectrophotometric evidence that flavin-containing enzymes form rather stable free radical intermediates (13), which are apparently identical to the free radical, verdoxflavin, described by Michaelis in nonenzymatic oxidation-reductions (14). We find that verdoxflavin yields a typical electron spin resonance, with *g* = 2.005.

It is probable, therefore, that the signals observed in the cytochrome reductase system represent, at least in part, electron spin resonance arising from free radical intermediates in the oxidation-reduction of both diphosphopyridine nucleotide and the enzyme's flavin prosthetic group. It cannot yet be determined whether the observed electron spin resonance may also include contributions due to reduced cytochrome *c* and cytochrome oxidase, which might produce an electron spin resonance with a rather high value of *g*.

With respect to the several systems studied, the foregoing results appear to confirm Michaelis' hypothesis that free radical intermediates occur in enzymatic oxidation-reduction processes.

## Chloroplast System

An electron spin resonance, which is augmented by illumination, was discovered in isolated tobacco chloroplasts by Commoner, Heise, and Townsend (10). This observation has been recently confirmed (15). From the extensive studies of a number of investigators (16), it is known that such preparations contain (i) the chlorophyll-lipoprotein complex which absorbs incident photons; (ii) enzyme systems which together with the chlorophyll complex catalyze the photolysis of water, with the release of O<sub>2</sub> when a suitable electron acceptor is present; and (iii) various electron-transport systems, especially those involving the cytochromes, ascorbic acid, flavin mononucleotide, and triphosphopyridine nucleotide.

The electron transport systems may be expected to develop free radical intermediates of the type already discussed, and the chlorophyll complex, when activated by light, has on theoretical grounds been supposed to form an excited triplet state (which is a biradical,

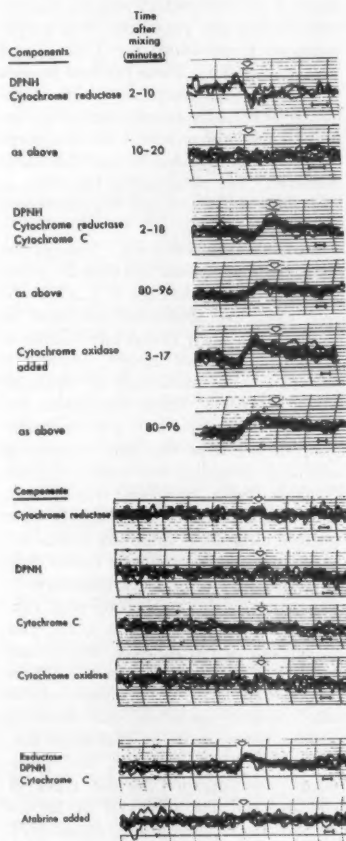


Fig. 3A (Top). Electron spin resonance from the cytochrome reductase system: 8 mg of reduced diphosphopyridine nucleotide, 30 mg of cytochrome reductase (prepared from pig heart by the method of Edelhoch *et al.*, 22), 30 mg of cytochrome *c*, 30 mg of cytochrome oxidase (prepared from beef heart by the method of Waino *et al.*, 23), and 0.1 ml of glycyl glycine buffer, pH 8.7. The tracings have been normalized with respect to the ESR position. Other procedures were the same as those described in the legend for Fig. 1. Fig. 3B (Bottom). Results obtained from control runs of the separate components of the cytochrome reductase system (four upper runs), and from the addition of 30 mg of atabrine to the complete system 20 minutes after the reaction began. Other procedures were the same as those described in the legend for Fig. 1.

and therefore presumably capable of yielding an electron spin resonance) or components of the semiconductor type (6, 15).

In the initial studies of Commoner, Heise, and Townsend, it was shown that the chloroplast preparations respond to illumination by generating an electron spin resonance which, on the basis of the evidence then available, was ascribed to

either the light-excited chlorophyll complex or the electron-transport enzyme systems associated with photosynthesis, or both. In what follows, it is shown that both types of constituents occur and that experiments with electron spin resonance are capable of elucidating, in part, the electron transport processes related to photosynthesis.

When chloroplast preparations are examined in the dark, an electron spin resonance is observed which exhibits characteristics that are consistent from preparation to preparation (see Table 1 and Figs. 4, 5, and 6). These can best be seen from the ESR absorption, which is obtained by machine integration (on an automatic analog computer) of the absorption derivative yielded by the ESR spectrometer. (The relationship between the absorption derivative and the absorption is illustrated in Fig. 5).

Electron-spin-resonance absorptions obtained from various chloroplast preparations are shown in Figs. 4, 5, and 6. In each case, the absorption exhibited in the dark is a fairly broad line (width at one-half maximum height, about 19 gauss) with a maximum at approximately  $g = 2.005$ . These absorptions appear to be resolved into a symmetrical group of five hyperfine lines of unequal amplitude extending over a span of about 25 gauss. Such compact, symmetrical, and unequal hyperfine groupings near the free electron  $g$  value are characteristic of organic free radicals rather than paramagnetic ions or semiconductors.

In general, the peaks observed conform to the amplitude ratio 3/2/1 (for the central, first peripheral, and second peripheral peaks, respectively). There is a limited number of atomic nuclei with magnetic moments, that occur in considerable quantity in biological materials: hydrogen, nitrogen, and phosphorus. Consideration of the types of hyperfine splitting observed in known free radicals containing these atoms (17) indicates that, for instances in which only five lines occur, the ratio of 3/2/1 is uniquely associated with free radicals in which the unpaired electron is in the neighborhood of two chemically equivalent nitrogen atoms. The splitting observed in electron spin resonance in the dark (6 to 7 gauss) is in the range of splittings which have been found in a number of free radicals containing two equivalent nitrogen atoms in a conjugated structure (18).

In a few preparations, we have observed what may be an additional pair of weak hyperfine lines on the periphery of the main electron spin resonance. This may indicate that the five lines of the electron spin resonance in the dark are but the most intense components of a more complex structure. Resolution of this question may lead to specific infor-

mation concerning the chemical nature of the substance responsible for the electron spin resonance observed in unilluminated chloroplasts.

Figures 4, 5, and 6 also show the results obtained when the chloroplast preparations are illuminated. In all cases, the electron spin resonance is increased in amplitude over the value obtained in the dark. The relative concentrations of unpaired electrons in various preparations can be estimated from the areas of the respective integrated ESR absorptions. Figures 4, 5, and 6 show that, as the chloroplast preparation is more extensively washed or dialyzed, the electron spin resonance in the dark decreases in amplitude, while maintaining its characteristic hyperfine structure. In contrast, the resonance in the light

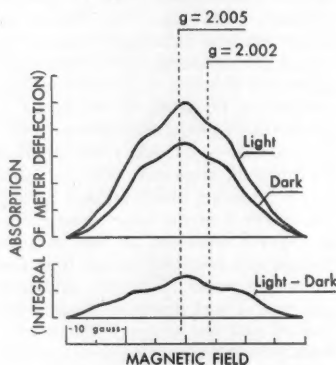


Fig. 4. Electron spin resonance from unwashed spinach chloroplasts in 0.5M sucrose. The absorption curves were obtained from the absorption derivatives yielded by the spectrometer (see Fig. 5, for an example) by means of an automatic analog computer. Illumination was with light from a 500-watt tungsten projection lamp filtered through 5 cm of 0.5-percent  $\text{CuSO}_4$  solution. Magnetic field increases to the right. Ambient temperature: about 35°C.

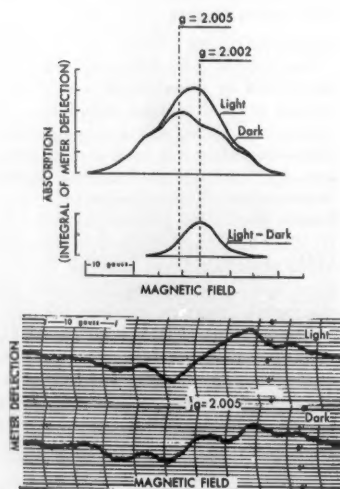


Fig. 5. Electron spin resonance from spinach chloroplasts washed twice with 0.5M sucrose solution. The lower curves represent the actual spectrometer records, and the upper curves represent the integral curves derived from them. Other experimental details as described in Fig. 4.

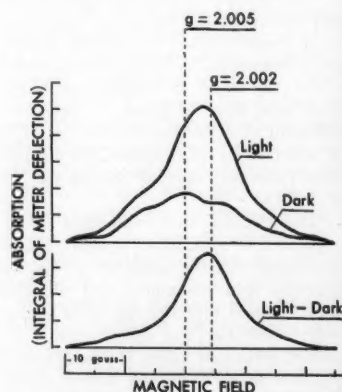


Fig. 6. Electron spin resonance from spinach chloroplasts washed and dialyzed against 3 lit of 0.5M sucrose solution at 4°C over a 24-hour period. The curves represent integrals obtained from spectrometer records of the type shown in the lower part of Fig. 5. Other experimental details as described in Fig. 4.

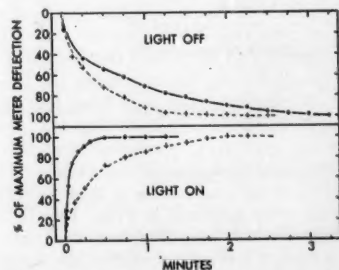


Fig. 7. Electron-spin-resonance meter deflections (after onset and cessation of light) for a spinach chloroplast preparation in 0.5M sucrose solution (broken lines), and the same preparation after dialysis against distilled water (solid lines). The points were read off spectrometer records of the type shown in the upper part of Fig. 8.



Table 1. Characteristics of electron spin resonances of spinach chloroplast preparations and living *Chlorella* cells.

Type of preparation	Width at one-half maximum of ESR absorption line (gauss)		Hyperfine splitting (gauss)	
	Dark	Light minus dark	Dark	Light minus dark
Chloroplasts, unwashed and undialyzed, in 0.5M sucrose	19	21	6	6 to 7
Chloroplasts, washed but undialyzed, in 0.5M sucrose	19	8	7	None
Chloroplasts, washed and dialyzed, in 0.5M sucrose	19	11	6 to 7	None
<i>Chlorella</i> , living cells	19	19	About 7	About 7

shows a relatively constant amplitude.

The shapes of the electron spin resonances of various illuminated preparations are complex and different from one another. The electron spin resonance exhibited during illumination is the sum of the electron spin resonance in the dark and the additional resonance induced by light; the latter can be extracted from the data by subtracting the resonance in the dark from that in light. These difference curves are shown in Figs. 4, 5, and 6.

When a chloroplast suspension which has been exposed to minimal washing is illuminated, the light-induced electron spin resonance is identical in  $g$  value, width, and shape with the original electron spin resonance in the dark (Fig. 4). Hence, in this case, the unpaired electrons generated by light appear as an additional amount of the free radical previously present in the unilluminated chloroplasts.

However, as the preparation is progressively washed and dialyzed, and the magnitude of the electron spin resonance in the dark is decreased, illumination induces the appearance of a new electron spin resonance. This new absorption differs from the electron spin resonance in the dark in three respects. (i) The absorption peak occurs at a magnetic field which is the same, within the few parts in  $10^4$  accuracy presently available, as that of a free electron ( $g = 2.002$ ); in contrast, the  $g$  value of electron spin resonance in the dark is 2.005. (ii) The resonance line lacks resolvable hyperfine splitting, whereas such splitting does occur in the dark resonance. (iii) The line width is about 8 to 10 gauss, as against about 20 gauss for dark resonance. These characteristics are evident in the difference curves obtained from washed and dialyzed chloroplasts (Figs. 5 and 6). The slight absorption on the periphery of these difference curves suggests that the dark resonance may also contribute slightly to the effect of light.

The light-induced electron spin resonance at  $g = 2.002$  appears to be associated with the chlorophyll-lipoprotein complex. Takashima (19) has reported the isolation of crystal-like rosettes of chlorophyll-lipoprotein by extraction of chloroplasts in  $\alpha$ -picoline, followed by extensive dialysis and final precipitation by addition of dioxane (20). When the dark green rosettes prepared from spinach chloroplasts in this way are examined in the ESR spectrometer, they exhibit a weak signal in the dark which is significantly augmented on illumination. The absorption occurs at about  $g = 2.002$  and exhibits a half-width of about 12 gauss. In these respects, it resembles the light-induced electron spin resonance of dialyzed spinach chloroplast preparations.

This observation and the persistent association of the resonance at  $g = 2.002$  with dialyzed and water-disrupted chloroplasts indicate that this electron spin resonance arises from light-induced, unpaired electrons in the chlorophyll-lipoprotein complex. That the line is relatively narrow and the  $g$  value close to that of the free electron suggest that the light-excited complex may be somewhat analogous to a semiconductor. Recent investigations by Arnold and Sherwood on the conductivity of dry chloroplast films lead to the same conclusion (21).

If the ESR spectrometer is set at the magnetic field at which the maximum absorption of microwave energy occurs, the meter deflections induced by turning the light on and off can be recorded against time, in the manner illustrated by the curves shown in Figs. 7 and 8. Such records provide a kinetic analysis of the responses of the several types of chloroplast preparations.

Dialysis has a marked effect on the rates of response of chloroplast preparations to onset and cessation of light (see Fig. 7). A preparation which has been washed in sucrose solution, but not dialyzed, achieves one-half of its maximum

response to light at about 15 seconds after onset. The half-time for decay in the dark is nearly the same, 14 seconds. In contrast, after the same preparation has been dialyzed against water, one-half of the maximum light-induced deflection is obtained at 2.2 seconds after onset, while the decay curve exhibits a half-time of 25.5 seconds.

Thus, dialysis enhances the rate at which the light-induced electron spin resonance appears and reduces the rate of decay in the dark. As noted previously, dialysis also reduces the amplitude of electron spin resonance in the dark and induces the appearance, in the light, of the electron spin resonance associated with the chlorophyll complex. Taken together, these facts suggest that chloroplasts contain a diffusible component which transfers unpaired electrons from the light-activated chlorophyll complex to the free radical which gives rise to the electron spin resonance in the dark. Conceivably, this component and the free radical responsible for the dark resonance are identical. In unwashed and

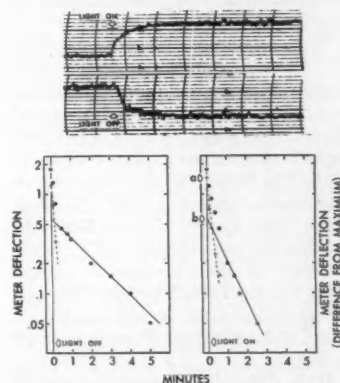


Fig. 8. Variation with time, after onset and cessation of light, in the ESR meter deflection obtained from a chloroplast preparation briefly dialyzed against 0.5M sucrose. The two upper curves show the change in the magnitude of the ESR signal (that is, the meter deflection at the magnetic field at which this deflection is at its first maximum) with time after the onset and cessation of illumination. The lower figures represent semilogarithmic plots of the meter deflections against time. Solid circles represent points taken from the actual records (above). The solid line represents the slow response, with intercept  $b$  being the contribution of this response to the total deflection. The broken line represents the fast response which is determined by the difference between the total response (solid circles) and the extrapolated line (solid) representing the slow response. The contribution of the fast response to the total meter deflection is represented by the intercept of the broken line at time zero (point  $a$ ).

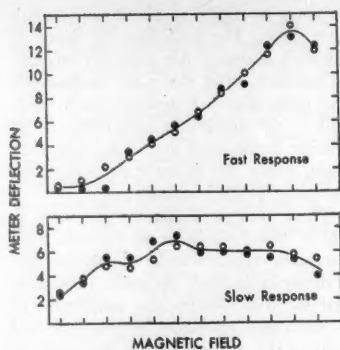


Fig. 9. Contribution of fast and slow responses to the meter deflection at a series of magnetic fields when a spinach chloroplast preparation in 0.5M sucrose is illuminated and darkened. Open circles refer to the increase in meter deflection on illumination. Closed circles refer to the decrease in meter deflection when the light is turned off. The points which determine the fast response curve represent intercepts such as *a* of Fig. 7; the points which determine the slow response curve represent intercepts such as *b* of Fig. 7. Each division of the abscissa represents about 0.8 gauss. Other experimental details as described in Fig. 4.

undialyzed chloroplasts, this transfer system is fully active. As a result, unpaired electrons generated by light in the chlorophyll complex are rapidly transferred to the free radical. In this circumstance, illumination augments only the resonance due to this free radical, the steady-state concentration of unpaired electrons in the chlorophyll complex being too small for detection. This condition is illustrated by the results obtained with unwashed chloroplasts shown in Fig. 4.

If the diffusible component is removed by dialysis, the rate of electron transfer from the light-excited chlorophyll complex is reduced. The steady-state concentration of unpaired electrons in the complex is thereby enhanced, and under illumination the electron spin resonance characteristic of the chlorophyll complex ( $g=2.002$ ) is then detectable as a signal superimposed on the five-component dark resonance centered about  $g=2.005$ . This condition is illustrated by the responses of the washed and dialyzed preparations shown in Figs. 5 and 6.

These considerations suggest that, in preparations that have not been totally freed of the diffusible carrier, illumination will generate electron spin resonances due to both the electron-transport free radical and the activated chlorophyll complex. The latter represents an inherently rapid photoactivation process upon which the former is dependent. Hence, of the two signals, the resonance

due to the chlorophyll complex ought to appear more rapidly in the light and decay more rapidly in the dark.

This hypothesis is subject to experimental verification. Figure 8 shows the time course of the response of a partially dialyzed chloroplast preparation to onset and cessation of light. A plot of the log of the deflection against time shows that the responses are complex exponential functions. At least two processes are involved. The faster process has a half-time of about 5 to 10 seconds for both onset of light and decay. The slower process has a half-time of about 40 seconds for onset of light, and about 100 seconds for decay. The relative contributions of the fast and slow processes to the total ESR meter deflection can be calculated from the semilogarithmic plot by the procedure described in Fig. 8. At the magnetic field at which the maximum meter deflection takes place, the fast process accounts for about two-thirds of the total.

By means of a similar experiment it is possible to characterize the separate electron spin resonances responsible for the fast and slow responses. Measurements such as those shown in Fig. 8 are made at a series of fixed magnetic fields beginning at a value below the center of the resonance and continuing to a field strength just past the first maximum deflection in the derivative curve. From a semilogarithmic plot of these data, the relative contributions of the fast and slow processes are determined at each value of the magnetic field. From these values, one may plot the separate fast and slow meter deflections as a function of the magnetic field. This plot, which is shown in Fig. 9, describes, in part, the electron spin resonances individually responsible for the two processes.

The fast process is apparently associated with an unstructured resonance, while the slower process is the result of a resonance which may exhibit a hyperfine splitting. The maximum deflection of the fast resonance occurs at a magnetic field about 4 gauss above the maximum of the slower resonance. Comparison of these results with the data of Figs. 4, 5, and 6 indicates that the fast response resembles the electron spin resonance associated with the light-activated chlorophyll complex, while the slow response resembles the resonance due to the electron-transport free radical.

From this evidence, it may be concluded (i) that the unstructured electron spin resonance at  $g=2.002$  represents unpaired electrons associated with the chlorophyll lipoprotein complex; (ii) that this resonance is uniquely dependent on light, and on illumination is generated at a rate which probably exceeds the spectrometer's time of response; and

(iii) that this resonance decays in part by means of electron transfer, via a diffusible component, to the organic free radical responsible for five-component electron spin resonance centered about  $g=2.005$ . This free radical itself may be diffusible.

These conclusions are in keeping with expectations based on the photochemical and oxidation-reduction processes which occur in chloroplast preparations. The light-excited state of the chlorophyll complex which gives rise to the resonance at  $g=2.002$ , may be viewed as the product of the primary photochemical process of photosynthesis. The resonance centered at  $g=2.005$  may be ascribed to a free radical form of one of the constituents of the electron-transport system which mediates the transfer of electrons from the primary photochemical process to the subsequent chemical events of photosynthesis.

### Living Cells

A goal of these investigations has been the elucidation of electron-transport systems within intact, functional, living cells. The studies just described have accordingly been extended to encompass, at least in a preliminary way, the activity of living cells of *Chlorella*.

If densely packed suspensions of freshly harvested cells of *Chlorella pyrenoidosa* (Emerson strain 3) are exam-

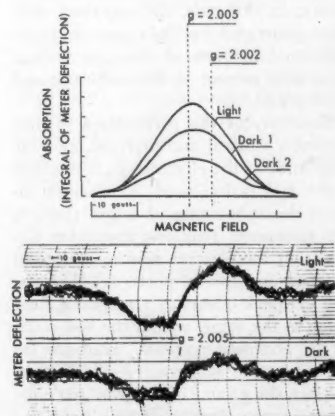


Fig. 10. Electron spin resonance of a suspension of living cells of *Chlorella* in the light and in the dark before illumination (Dark 1) and after illumination (Dark 2). The cells were suspended in a salt solution free of trace elements after being harvested from a nutrient containing urea, trace elements, and basic salts. The lower curves represent successive tracings of the direct spectrometer signals; the upper curves are integrals derived from such tracings. Other experimental details as described in Fig. 4.



ined in the ESR spectrometer, results such as those shown in Fig. 10 are obtained. These cells exhibit an electron spin resonance in the dark, which is enhanced by illumination. In both conditions, the  $g$  value is about 2.005 and the line width about 19 gauss. In these respects the electron spin resonance of *Chlorella* cells is similar to the resonance line centered at  $g = 2.005$  previously found in spinach chloroplasts. This resemblance is reinforced by the lowermost curve shown in Fig. 10, which represents the electron spin resonance obtained from the *Chlorella* preparation when it is again darkened after a period of illumination under relatively anaerobic conditions. This electron spin resonance exhibits some indication of hyperfine splitting, which, while it is less well resolved than the structure shown by spinach chloroplasts, appears to be based on the same splitting.

These results show that living *Chlorella* cells, like the chloroplast preparations, respond to illumination by generating unpaired electrons. The characteristics of the *Chlorella* electron spin resonance are similar to those of the free radical, which in relatively intact chloroplast preparations gives rise to the five-component resonance line centered at  $g = 2.005$ . Thus, in both the living cell and in the unwashed chloroplast, light-induced, unpaired electrons appear to be rapidly transferred from the primary photochemical component to a free radical constituent of the electron-transport system, where they give rise to a detectable change in steady-state concentration.

The behavior of *Chlorella* cells in the ESR spectrometer is more complex than that of isolated chloroplasts. The structure of the *Chlorella* electron spin resonance changes with time, especially after the light is turned off, and in the dark shows evidence of a number of closely spaced hyperfine bands not detected in chloroplasts. Although illumination does not appear to change the  $g$  value or band width, it does seem to suppress structure, possibly because new free radical species contribute to the signal.

The results obtained with *Chlorella* are consistent with the chloroplast data already described and indicate that the operation of the intact photosynthetic system in the living cell involves univalent electron-transfer processes.

## Conclusions

The foregoing results show that in the several instances studied, components that contain unpaired electrons occur as intermediates in biological oxidation-reductions. Although the electron spin resonance signals thus far obtained from isolated oxidation-reduction enzyme systems are too small to permit a detailed characterization, the observed  $g$  values are consistent with those exhibited by organic free radicals. The kinetic behavior of the electron spin resonances observed in enzyme systems and their response to variations in system constituents are in keeping with Michaelis' hypothesis that biochemical oxidation-reduction occurs in successive univalent steps which give rise to free radical intermediates. As experimental procedures are improved, and more intense signals are obtained, it should prove possible to determine the specific molecular composition of the free radical intermediates of these and similar enzyme systems.

The detection of the five-component electron spin resonance line centered at  $g = 2.005$  in chloroplasts is perhaps more complete evidence for the participation of a specific organic free radical in biochemical oxidation-reduction. The fine structure which it exhibits is of a type observed only among organic free radicals. The enhanced amplitude of this electron spin resonance in illuminated unwashed chloroplast preparations, and apparently in living *Chlorella* cells as well, is evidence that the free radical from which it arises participates in the electron-transport process associated with photosynthesis. This result supports the less detailed data on isolated enzyme systems as evidence of the general validity of Michaelis' free radical hypothesis.

The results of the studies of isolated chloroplasts, and living cells of *Chlorella* provide evidence in support of the proposal that the flow of electrons associated with photosynthesis is a univalent process. The data provide direct support for Szent-Gyorgyi's suggestion that the chloroplast is analogous to a semiconductor and show that the ESR technique is capable of analyzing the interactions among components of this complex metabolic process.

The results obtained with *Chlorella* may be regarded as direct evidence of the participation of a specific free radi-

cal in the metabolic activity of a living cell. Electron spin resonances have also been obtained from other living cells, including several species of bacteria and mammalian tissues.

In the aggregate, these results appear to establish the usefulness of the ESR technique as a new means for analyzing the physical mechanisms of biochemical processes.

A final comment is pertinent. Ten years ago, Leonor Michaelis wrote of his free radical hypothesis "The road for the exploration of individual metabolic catalyses will be long. Although it is still far ahead, one is encouraged to believe that the correct road sign has been found" (1). The foregoing results are a tribute to his foresight.

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# Communication in le Scientia

Forrest F. Cleveland

Ralph E. O'Dette, in un recente articulo (1) super "Russian translation" (Traduction russe), listava tres alternativas pro facer le resultados scientific del mundo disponibile al scientistas. Istos esseva (i) traduction del articulos ab le lingua original (pro exemplo, russo) in altere linguas (pro exemplo, anglese); (ii) publication de resultados scientific in un lingua international, tal como arabe, greco, latino, o interlingua; e (iii) placiamiento de plus emphase super le instruction in linguas (pro exemplo, russo) pro le studentes del scientia.

## Traduction de Articulos

Le traduction de articulos ab un lingua a altere linguas, o le traduction e republication de jornales complete, es un processo costose e inefficiente. Extra le costo, le retardo necessari pro le traduction e republication usualmente face le articulo minus valorabile que illo haberea essite al tempore de su publication original. E tunc il haberea errores in le processo de traduction o de reimpression.

## Plus Instruction in Linguas

Le inseniamento de plus linguas al studentes de scientia requirea un

Dr. Cleveland is a member of the department of physics of Illinois Institute of Technology, Chicago. This article, written in Interlingua, is of special interest in connection with the editorial on page 55.

amonta substantial de tempore ex le vita del scientista. Isto es regrettabile, in despecto del facto que un tal studio de linguas ha un certe valor cultural. Al presente, es requirite ab le studente in le programma pro le grado doctor de philosophia que ille ha alicun facilitate de lectura de duo linguas in addition a su lingua native. In practica, isto significa que le studente pote leger sufficientemente ben con un dictionario pro passar le examination de lectura. Illo usualmente non significa que ille es realmente competente in le lectura del duo linguas. Consequentemente, si on adde un tertie lingua, on reduce plus le tempore que le studente pote passar super su education in le scientia, sin grandemente accrescer su facilitate pro absorber rapidamente le nove ideas que appare in le litteratura scientific.

De plus, etiam un tertie lingua es solmente un comenciamento. Le resultados scientific es publicate in un grande numero de linguas. Le scientista non pote sperar comprender multo de istos.

E, in addition al tempore e expensa del studente, il ha le grande costo de provider le instruction additional in le linguas.

## Publication in un Lingua International

Le melior del tertie alternativas pare clarmente esser le publication de omne resultados scientific in un singule lingua international, preferibilmente un que ha un grammatica multo simple e un

que esserea legibile praticamente a prime vista per alicun scientista. Si omne le resultados scientific esseva assi publicate, le scientista tunc poterea realmente mastrar iste un lingua sin un grande perdita de tempore. Ille haberea tunc un accesso personal e immediate al ideas e informationes que appare in le litteratura scientific del mundo.

Isto esserea si multo minus costose in tempore e moneta, e si multo plus efficace in le dissemination de informationes scientific. Illo es clarmente un fin grandemente a esser desirata. Le avantiamiento de scientia esserea accrescite tremendemente si iste objectivo esserea attingite.

## Un Experimento del Autor

Le autor es ingagiate in un experimento in publication in un tal lingua. Depost maio 1952, ille ha redigite e publicate in su mesme campo de recerca un parve periodico mensual, appellate *Spectroscopia Molecular*, in le nove lingua international, interlingua. Iste periodico es nunc inviate a 800 spectroscopistas e bibliothecas in 37 paises. Experientia demonstra que le recipientes pote leger illo sin difficultate a que illes senti que le periodico es un servicio de valor in iste campo al nivello international.

Le objectivo es distribuer novas e informationes (includente annunciations de companias) de interesse e valor al spectroscopistas molecular e supportar le periodico completamente per contributiones financiari ab le spectroscopistas, bibliothecas, e companias que beneficia de su existentia. Le receptas del periodico ha essite sufficiente pro pagar le costos e pro accumular un reserva que assecura publication pro un anno in avantia.

Le reception sympathetic de iste parve periodico suggere que le tempore poterea esser plus matur que haberea essite expectate pro le publication de resultados scientific in un lingua international.

## Reference

1. R. E. O'Dette, *Science* 125, 579 (1957)

## J. W. Kennedy, Scientist, Teacher, Leader

In the death of Joseph W. Kennedy, on 5 May 1957, the world lost a brilliant scientist, an inspiring teacher, a wise leader, and a warm friend. In addition to his outstanding scientific career, many will remember him for his keen, inquiring mind, his originality, his quick wit and entertaining stories, his persuasive arguments, his integrity, his wisdom, and his kindness.

Kennedy was born in 1916 in Nacogdoches, Texas. He received his A.B. degree from Stephen F. Austin State Teachers College, in 1935, his M.A. degree from the University of Kansas, in 1937, and his Ph.D. degree from the University of California, in 1939. He served as instructor in chemistry at the University of California from 1939 through 1942. In 1943 he organized the Chemistry-Metallurgy Division at the new Los Alamos Laboratory and served as its division leader through 1945. In 1946 he came to Washington University, St. Louis, Missouri, where he served as Eliot professor of chemistry and chairman of the department of chemistry until his death.

His principal research interests were in the field of radiochemistry, but his scientific interests and knowledge extended to all fields of chemistry and physics. His brilliant mind was able quickly to comprehend any subject and to get immediately to the heart of a problem.

Kennedy's first publications (1939) concerned the identification and chemical separation of nuclear isomers. His work led to the identification of the isomers of tellurium-131, tellurium-129, tellurium-127, and zinc-69 and to the understanding of the importance of the internal-conversion process in the chemical separation of nuclear isomers.

His research accomplishments were many, but he is probably best known for the important part he played in the discovery of the element plutonium and the determination of the fission properties of plutonium-239. He not only contributed many of the important ideas for experiments, and their interpretations, but he designed and built the detection instruments that were essential

to the work. The thin-window Geiger and proportional counters, the ionization chambers, and the linear amplifiers which Kennedy designed and built were new and novel to radiochemists in 1940 and had much to do with the early success of the Berkeley radiochemistry group.

In 1943 Kennedy was chosen to organize the Chemistry-Metallurgy Division of the new and highly secret Los Alamos Laboratory. The division started with perhaps a dozen scientists and grew to number them in the hundreds, as the magnitude and difficulties of the chemical and metallurgical problems became apparent. Nothing seemed impossible; the only questions concerned the quick-est and best approaches to the problems. For these, Kennedy was an inexhaustible source of ideas. He inspired the members of his division to great efforts and had the vision and wisdom to lead them through expansion and building pains, past personnel misunderstandings, and over new and immense technical problems. He took a personal interest in his men and helped many of them find suitable positions after World War II. Kennedy, then only in his twenties, enjoyed the respect and confidence of all the men in his division and of the many others in the laboratory with whom he worked. For his outstanding contribution at Los Alamos he received the U.S. Army Medal of Merit, the highest military award that is bestowed on a civilian.

In 1946, when he came to St. Louis to become chairman of the department of chemistry at Washington University, he brought from Los Alamos a number of his associates to take positions on the chemistry faculty and some to do graduate work in chemistry. His enthusiasm for teaching and research were contagious. New courses and new research projects were started, and these developed into sound undergraduate and graduate programs of study and research.

With his graduate students, Kennedy contributed to a number of branches of radiochemistry. In hot-atom chemistry, the effects of positron decay in the  $\text{Mn}^{51} \rightarrow \text{Cr}^{51}$  transition were studied. In

kinetics, the iodine-iodate isotopic exchange reaction was investigated with a thoroughness that is seldom found in kinetic work. He pioneered in quantitative rate measurements of oxygen-18 exchange reactions. He and his students investigated, with care and precision, the kinetics of oxygen exchange between water and sulfuric acid and between water and phosphoric acid.

He made major contributions in the field of self-diffusion of ions in aqueous solution. With his students, he developed new techniques, which were studied and refined until they were proved to be reliable. The self-diffusion of  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Rb}^+$ ,  $\text{Cs}^+$ ,  $\text{Cl}^-$ , and  $\text{I}^-$  were studied over wide ranges of concentration.

Kennedy liked best the experiments that were novel and exciting. Shortly after the war he made calculations, planned experiments, and built equipment for the detection of positronium, before its discovery was announced.

He studied bacteriophage containing radioactive phosphorus to learn about the source of phosphorus in the progeny and, from this, perhaps something about the reproductive mechanism.

His most recent work concerned the generation of high potentials by insulated radioactive sources. He had hoped to build a "poor man's accelerator"—a device consisting of a series of beta sources that could attain a potential of approximately 12 Mev. The potential, unfortunately, was limited by vacuum conduction, and the scope of the problem changed to a study of the conduction mechanism. Kennedy believed that if the mechanism were understood, the conduction might be controlled.

Kennedy was an outstanding teacher. He had the rare ability to express himself clearly and concisely and to explain complex concepts in simple and exciting language. His quick wit and wealth of stories added to the interest of his lectures.

He taught, for many years, a graduate course in radiochemistry. For the textbook, he wrote, with Gerhart Friedlander, *Introduction to Radiochemistry*, which they revised in 1955 and published under the title *Nuclear and Radiochemistry*. This contains a wealth of information, presented clearly and logically, and is widely used as a textbook and reference book.

Kennedy enjoyed teaching chemistry to freshman. He liked working with the students and was sympathetic and understanding of their problems. By creating interest in chemistry at the freshman level, he was able to attract promising students to careers in chemistry.

Under Kennedy's wise and inspiring leadership, the department of chemistry at Washington University has grown steadily in stature. Graduates are in

great demand, and students and visitors are attracted from all parts of the United States and from many other parts of the world.

Kennedy served with tireless energy on numerous university committees. His services were also in great demand outside the university. He served as a civilian with the U.S. Office of Scientific Research and Development in 1944 and later served on other governmental committees, including the Atomic Energy Commission's Reactor Safeguard Committee. He was consultant or adviser to the Brookhaven, Los Alamos, and Oak Ridge national laboratories and to the

General Atomics Corporation and the Polaroid Corporation.

He was secretary (1952), vice chairman (1953), and chairman (1954) of the Division of Physical and Inorganic Chemistry of the American Chemical Society. In 1952 he gave the Priestley lectures, on "Radioactive atoms and isotopic tracers," at Pennsylvania State University.

Something of Kennedy's courage and his faith in science is shown by his last scientific effort—a search for a cure for cancer, the disease which took his life. After reviewing the many approaches that were being followed, he concluded

that a very promising but neglected one was the destruction of cancer cells by the  $B^{10}(n,\alpha)Li^7$  reaction. He believed that boron compounds could be found that would be selectively absorbed, as are some amino acids, by cancer cells, which could then be destroyed by neutron irradiation. His last experiments were attempts to synthesize such compounds. These experiments are being continued by two of his former colleagues, under a grant which he helped to arrange.

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## News of Science

### German Scientists Not Required to Work on Nuclear Weapons

Chancellor Konrad Adenauer of West Germany reversed his point of view a few days after he had criticized 18 of his country's nuclear physicists who had stated on 12 Apr. that they would refuse to work on atomic weapons [*Science* 125, 876 (3 May 1957)]. Adenauer joined with Defense Minister Franz-Josef Strauss, NATO Commander Hans Speidel, and other high officials of the West German Government in an all-day conference with five of the scientists who had signed a public protest—Otto Hahn, Max von Laue, Carl-Friedrich von Weizsäcker, Walther Gerlach, and Wolfgang Reizler.

The conference resulted in a joint communique that included the following statements:

"The Federal Chancellor and the gentlemen of science who took part in the discussion believe it is necessary to appeal to all Governments, East and West, with all available means in order to achieve an agreement on a general controlled disarmament that might liberate the people of the world from the fear of an atomic war. . . .

"It was clarified that the Federal Republic now as before will not produce its own atomic weapons and therefore the Federal Government sees no cause to request German nuclear scientists to participate in the development of these weapons."

### Nuclear Clock at Brussels World's Fair

The \$5-million United States Pavilion for the 1958 Brussels World's Fair was dedicated recently. Concurrent with the dedication ceremony was the installation of a nuclear clock that will measure time through the disintegration of radioactive substances, radium-226 and tantalum-182. The instrument is set for the 6 months of the fair, which will run from 17 Apr. 1958 through 19 Oct. 1958. The nuclear timepiece, symbolizing this country's atoms-for-peace program, was demonstrated by T. O. Jones, acting coordinator of the science program for the American exhibition.

### Asian Flu

A mild outbreak of influenza, believed to be of the Far East type, has been reported by the Navy on ships of the Atlantic fleet stationed in Newport, R.I. There were an estimated 550 cases on eight of 110 ships. The cases are usually mild, but the virus appears to be highly contagious.

The United States Public Health Service has announced that a new monovalent vaccine is currently being tested on 60 volunteers in Montgomery, Ala. The U.S. Department of Defense has placed an order for 4 million injections for the armed forces if the experimental vaccine proves effective.

### News Briefs

The Vanguard Computing Center, where high-speed electronic calculations will predict future orbits of U.S. earth satellites, opened on 2 July in Washington, D.C. The center will be operated under a Navy contract by International Business Machines Corporation.

Tadayoshi Doke, assistant professor at St. Paul's University, Tokyo, reported recently that radioactive contamination over Japan had increased by 12½ times in the last 2 years.

The Soviet news agency Tass reports that the Soviet Union has built a large hydrological laboratory at Valdai, near the source of the Volga River.

A radio observatory that will keep a constant record of disturbances on the sun's surface during the International Geophysical Year was dedicated on 30 June at the Rensselaer Polytechnic Institute.

A new corporation, NDA Europe, has been formed in Brussels by Belgium and United States interests to provide for rapid atomic energy development in the six Euratom countries and their colonies, possessions, and territories. The principal owners of the new corporation are Nuclear Development Corporation of America, White Plains, N.Y., and Société Générale des Minerais, Brussels.

The School of Medicine of the University of Missouri has been fully accredited by the Council on Medical Education of the American Medical Association as a complete 4-year school and voted full membership in the Association of American Medical Colleges.

The Muscular Dystrophy Associations of America, Inc., has announced plans to erect a \$3.5-million research laboratory and office building in New York.



## NAS and Hungarian Scientists

The material that follows was abstracted from an article in the May-June *News Report* of the National Academy of Sciences-National Research Council on "The Academy's role in the Hungarian scientists' fight for freedom," by Wallace W. Atwood, Jr., and M. H. Trytten [*Science* 125, 187 (1 Feb. 1957); 125, 541 (22 Mar. 1957)].

"The Academy in mid-December offered to initiate a program of professional evaluation and placement of scientifically qualified persons among the refugees arriving in the United States. This offer was promptly accepted by the President's Committee for Hungarian Refugee Relief, appointed on December 12 by President Eisenhower. Seven days later the Academy set up an office at Camp Kilmer, the official refugee reception center. . . . This office remained open continuously including Saturdays, Sundays, and holidays, through April 30, 1957, when the U.S. Immigration and Naturalization Service shifted all refugee operations to the Hotel St. George in Brooklyn, N.Y. The Academy immediately transferred its office to the new location, where it is currently operating. . . .

"Initiation of the Academy's activities in behalf of the Hungarian refugees was made possible by the fact that the Ford Foundation a year earlier had provided a substantial grant to the Academy for its work in international relations. A portion of this grant was made available immediately to launch the program. Later, the Rockefeller Foundation provided funds for evaluation and placement activities, language and orientation courses, and for a limited number of fellowship awards. Valuable professional assistance was rendered by the American Council for Emigres in the Professions, which maintained continuously a staff of two or three people at the Academy's office at Camp Kilmer and later at Brooklyn. . . .

"No one knew whether the operation would continue for a few weeks or several months. Each day brought new developments and new problems. In the face of these conditions the Academy organized its office under the joint direction of the Office of International Relations and the Office of Scientific Personnel. The authors of this article became co-directors of the operation, each spending part of his time at Camp Kilmer. . . . Continuity in direction was maintained by Edmund C. Rowan, Assistant to the Director of the Office of International Relations who was appointed Executive Officer. . . .

"Soon after the Academy's arrival at Camp Kilmer, it became clear that the first order of business was to make known

the existence of the Academy's office to the scientists and other professionally trained people among the refugees arriving at the camp. This was not as easy as might be expected; in fact, complete success was never achieved because eager relatives and sponsors hustled many of the refugees away from the camp almost immediately upon their arrival from Austria. However, more than 750 professional persons (holders of a college degree or the equivalent) came to the office. It is estimated that this figure represents approximately 60 percent of the total number of persons who might have profited by a visit to the Academy's office. Many of those who left camp without calling at the Academy's office have since returned as visitors or have written to the Academy to obtain advice concerning professional placement opportunities. . . .

"Each person was given a preliminary interview, at which time a questionnaire was completed by the interviewer. . . . For professional interviewing the Academy relied on the voluntary services of more than 30 professional members of the universities located within overnight range of Camp Kilmer. Eminent scientists from the Massachusetts Institute of Technology, Columbia, Princeton, Rutgers, Johns Hopkins, and other universities and academic centers gave generously of their time.

"Following the professional interview, a member of the Academy team, usually the placement officer, talked with the scientist concerning his own desires or plans. . . . A master file of position openings, containing literally hundreds of opportunities, was consulted. This file was compiled from the communications received from educational institutions and industrial firms, which had been invited by the Academy to assist in the program or had learned of the undertaking through the press. . . .

"However, all was not smooth sailing in the placement area. . . . There was the continuing problem of coordinating the Academy's work with that of nearly 20 voluntary agencies which were assisting the refugees. Because of the large number of refugees arriving, particularly in January, there was pressure to move people out as rapidly as possible, sometimes making it impossible to give adequate attention to professional placement. Frequently someone interviewed by the Academy disappeared overnight; he had been sent out to some part of the country where his professional placement possibilities were unknown. Physicians presented a special problem because many states make no provision for licensure of foreign trained physicians. Lawyers whose training and experience dealt with a different philosophy of law could not hope to practice their profession in the United States. The placement of en-

gineers, and others seeking industrial employment was complicated because interviews by private industry were not permitted at the camp.

"In spite of these difficulties the Academy's office at Camp Kilmer placed or assisted in the placement of more than 500 of the 750 refugees who visited the office. . . . Many of the scientists and engineers accepted industrial positions commanding salaries ranging from \$4,000 to \$15,000 per year. Others found opportunities in universities, research institutions, hospitals, libraries, agricultural experiment stations, and government research laboratories. Still others received pre-doctoral or post-doctoral fellowship appointments in graduate schools from coast to coast. A detailed analysis of the professional placements will be made when the Academy's program is concluded.

"It should be emphasized that in almost all instances the Hungarian refugees have filled positions for which American scientists and engineers were not available. . . .

"Early in the operation the need to provide training in English became apparent, because a number of the refugees could not be placed appropriately until they had acquired some fluency in speaking English. Fortunately through the warm cooperation of Lewis Webster Jones, President of Rutgers University, and David Denker, Assistant Provost, facilities were made available to the Academy in one of the University's new dormitories, and the language training program was launched. This course under the direction of Rev. Bradford Abernathy, Chaplain of the University, lasted 8 weeks. . . .

"Throughout the months of January and February letters arrived at the Academy's office at Camp Kilmer from Hungarian scientists stranded in Austria. . . . The Academy asked one of its members, Paul Weiss of the Rockefeller Institute, to go to Vienna to investigate. He reported that many of the refugees who had written to the Academy had arrived in Austria after December 1, 1956, and thus were not eligible to go to the United States under the parolee program. . . . Dr. Weiss proposed that the Academy establish an office in Vienna to help the scientists among the refugees still stranded there to find professional opportunities in the free nations of the world. . . . Procedures for coordination of Academy operations on both sides of the Atlantic were worked out, and an initial team was selected to undertake the assignment.

"On March 20, three people met at Idlewild Airport: Ralph Cleland, a botanist, Dean of the Graduate School at the University of Indiana; Richard T. Arnold, a chemist, Alfred P. Sloan Foun-



dation, Inc.; and Wallace W. Atwood, Jr., co-author of this article and a geologist-geographer, who was to serve as Director of the Academy's Mission to Vienna. The 18 hours of flying time to Vienna were devoted primarily to speculation. . . .

"A tentative plan was agreed upon: the [American] Embassy would provide space and office equipment for the Academy's operation and the INS would assist the Academy team on matters involving the Immigration Service. The purpose of the mission was clear. . . . Only one question remained unanswered: how many scientists were there among the refugees? . . . No one guessed that the actual total would exceed 500. . . .

"Arrival of the Academy's Mission in Vienna received no notice in the papers or on the radio. However, news of the Mission spread like wildfire and before the ink was dry on the forms, the first Hungarian scientists were knocking at the door. The Academy, however, was not willing to rely completely on the refugee grapevine and decided, therefore, that a formal message should be sent to the scientists and that it should be distributed to the refugee camps, the universities, and the various offices frequently visited by the refugees. . . .

"Distribution of the [message] had a surprising effect. Many scientists who had not requested immigration to any country and had not registered with any of the voluntary agencies literally came out of the woods. This development caused the Academy's team some concern because it had been expressly stated that refugee scientists who had found permanent professional employment in Austria should be encouraged to remain. But as it turned out, these people had no employment and urgently desired to find positions in other countries. Many of them are now on their way to the United States. Why these people had not registered with the immigration authorities is still a mystery. . . .

"Soon after the establishment of the Academy's Vienna office. . . . local newspapers announced that the United States had closed its doors. . . . Fortunately, the newspaper reports were incorrect. The door was closing, but refugees would continue to go to the United States under a restricted program.

"With this near catastrophe passed, interviews proceeded at an accelerated rate. In less than 8 weeks, 375 persons were interviewed. Dr. Arnold maintained a daily schedule from 8:30 to 6:00, 5 days a week. He was later aided by Arpad Csapo of the Rockefeller Institute, who interviewed the majority of the medical people among the refugees who called at the Academy's office. Additional professional interviewers included Samuel H. Williams, professor of zoology at the Uni-

versity of Vienna; Gabor Szego, professor of mathematics at Stanford University; and Lester Hawkins, a physicist on the staff of the U.S. Army Attache. The professional contributions of these American scientists, some of them temporary residents of Austria, made it possible for the Academy to carry out its mission. . . .

"It is appropriate to ask: How successful was the Academy's Mission to Austria? How many of those interviewed will actually reach the countries of their choice? Reports indicate that very few of the refugees seeking opportunities outside Austria failed to learn of the Academy's Mission, and all those whom the Academy believed it could assist within its restricted program were interviewed before the Mission departed. Although it is not possible as yet to say how many of these people will reach the countries of their choice, information currently available indicates that very few will fail to realize their desires. . . .

"This was a new type of activity for the Academy and, consequently, new methods of operation had to be devised. The major objectives of the Academy's participation in large measure have been attained. . . . Although the daily influx of Hungarian scientists has nearly ended, the Academy will maintain its Brooklyn office so long as it is needed to assist the remaining emigres to find places where they can exercise their talents in personal and scientific freedom."

### American Institute of Physics

The American Institute of Physics has moved its national headquarters from 57 E. 55 St., New York, to its new home at 335 E. 45 St., near the United Nations Plaza. The remodeled building increases by three times the amount of space available for the expanded activities of the institute, which is an association of five professional societies with more than 18,000 members in this country and abroad.

The institute—founded in 1931 by the late Karl T. Compton, Paul D. Foote, George B. Pegram, and their colleagues—is a unified service organization that includes the American Physical Society, Optical Society of America, Acoustical Society of America, Society of Rheology, and the American Association of Physics Teachers.

The new headquarters was made necessary by expansion of the number and activities of physicists during and after World War II. In the past 14 years, the AIP headquarters staff has grown from 25 to 65, its membership has more than doubled, and the number of journal pages published annually has increased more than four times.

One of the reasons for the move was

to ease the publishing crisis facing the field of physics; another was to provide for projects for improving the quality of physics teaching. At present, more than 19,000 pages appear in journals published by the institute; another 5000 pages are needed in order to report new research effectively. New journals are being planned and, in some instances, existing publications will be expanded.

### Japanese Geneticists on Radiation

The following "Statement concerning the genetic effects of radiation upon man" was prepared in April by the Genetics Society of Japan and the Japan Society of Human Genetics and sent out by them to a number of colleagues in other countries.

"With the increasing utilization of atomic energy, man inevitably has greater chance of being exposed to radiation than he has previously had. Generally speaking, any kind of radiations causes some damage to organisms. Particularly, their genetic effect is serious for the following reasons:

"1. It has been demonstrated by many experiments that radiations induce genetic changes or 'mutations' in organisms. Man cannot be exempt from this rule. Some such mutations occur naturally, but radiations raise their frequency.

"2. The great majority of these mutations are deleterious to mankind. Their effect may appear in the next generation, but more commonly only in subsequent generations. Therefore, the apparent escape of the next generation from such an effect does not ensure the genetic safety of all descendants.

"3. The incidence of mutation increases in proportion to the total dose of radiation given to the gonad. Whether irradiation is continuous or intermittent, the same amount of mutation is induced in either case, provided that the total dose is the same, since the mutation which was once induced persists even after the end of irradiation and is handed down to progeny. Thus the genetic effect of radiations through the gonad is fundamentally distinct from their direct damage to the body, which may disappear after the end of irradiation.

"4. Human population acquires natural mutations which are of very low incidence. These mutations are removed by natural selection, and the newly-appearing mutations and those removed by selection are mutually balanced; the incidence of mutant genes is thus kept in equilibrium. Additional mutations artificially induced by irradiation cause the break-down of this equilibrium, and an increase of the mutant genes possessed by the population. Such a change will lead to a gradual increase of individuals

handicapped in physical strength or in mental capacity, increases the sacrifices of individuals and the burdens of the society, and leads to eventual disaster for mankind.

"From what has been pointed out above, we are led to conclude that any amount of radiation, however small it may be, is deleterious to the heredity of man. Although a certain dose has been set as 'permissible' for people engaged in the operation of X-rays and radioactive apparatus or substances, this is only aimed at the safety and health of those people themselves. However, as far as the genetic effect on their descendants is concerned, there is no theoretical limit below which danger may be entirely excluded.

"Although there can be hardly any question about the necessity for the peaceful utilization of atomic and other radiation energies, it is still all the more important to guard against any misuse or misoperation of such energies. This is not only for the safety of the present generation, but also for the health and prosperity of our descendants. Also, we must be on guard against the genetic effects of atomic or hydrogen bomb tests, which increase the level of radioactive contamination in the air and water.

"Under such circumstances, we geneticists eagerly hope that the general public will realize the urgency of the question at issue, and that effective means for its solution will be taken promptly."

### Engineering College Survey

A national study now being conducted by the American Society for Engineering Education will evaluate the engineering research capabilities and potentials of American engineering colleges. Robert H. Ramsey, head of industrial reference in the College of Engineering at Pennsylvania State University, is director of the survey. The project has been made possible by a grant of \$40,000 from the National Science Foundation to the Engineering College Research Council, ASEE's group concerned with engineering colleges' research activities.

After 8 months of planning and organization by an advisory committee, the survey was launched at the end of June by eight interviewers who are visiting 108 accredited engineering schools during the summer. They will ask how much research experience and ability is represented on each faculty, how much of this is already being devoted to research activities, and how much more could be devoted to research if adequate assistance were available.

The final report, due in December, will include a figure for the colleges' total engineering research potential and

will provide an indication of the funds that may reasonably be appropriated for engineering college research. The survey will also report on facility deficiencies and equipment which would be needed to realize to a greater extent the research potential represented in the schools.

### Rheumatoid Arthritis Test

A new diagnostic test for rheumatoid arthritis which is so simple and rapid that it can be performed in a routine clinical laboratory in 20 minutes was reported by Joseph J. Bunim, John Bozicevich, and Jules Freund of the National Institute of Arthritis and Metabolic Diseases, Bethesda, Md., at the ninth International Congress on Rheumatic Diseases that took place recently in Toronto, Canada.

Known as the Bentonite flocculation test (BFT), the procedure was described as being as accurate as the best of current tests, yet it produces results in a few minutes rather than days. By means of the new test, the average medical technician would be able to perform 100 or more tests per day.

The procedure employs as its key element a type of colloidal clay known as Bentonite, which is mixed with normal human gamma globulin. A drop of blood serum from the person being tested is added to a drop of Bentonite-gamma globulin mixture on a slide. If the test is positive, the Bentonite particles will flocculate within a few minutes.

The BFT test was administered to 25 patients with typical rheumatoid arthritis, the patients ranging from 18 to 69 years of age. In 20 patients (80 percent), tests were positive. When applied to 163 control patients with other types of rheumatic disease as well as a wide variety of other disorders, only three tests (1.8 percent), resulted in false positive reactions.

Thus, in its present preliminary stage of development the test appears to be able to detect accurately eight out of ten cases of rheumatoid arthritis and to yield false positives in less than two out of 100 cases. It was emphasized that the report was preliminary and that findings had not yet been confirmed in other research laboratories.

### Howard Centennial Dinner

A centennial dinner in memory of Leland Ossian Howard, pioneer in American economic entomology, was held on 11 June in Washington, D.C. Howard, who died in 1950, was permanent secretary of the AAAS from 1898 to 1919 and its president in 1920. The dinner was sponsored by the Entomological Society

of Washington, for which he had also served as president, and the Insecticide Society of Washington.

The centennial was attended by 140 people, many of whom were entomologists who had known Howard when he was the chief of the Bureau of Entomology, U.S. Department of Agriculture. The guests of honor were Howard's daughters, Lucy and Janet, and his grandson, Howard Payne. The master of ceremonies and chairman of the dinner committee was Mortimer D. Leonard, one of the many entomologists who had been encouraged by Howard.

### Source Book for High-School Biology

The Committee on Educational Policies of the Biology Council, Division of Biology and Agriculture, National Academy of Sciences-National Research Council, reports that the summer writing conference to develop a source book of laboratory and field studies for high-school biology courses is under way at Michigan State University, cosponsor of the conference [*Science* 124, 1022 (23 Nov. 1956)]. The session, which began on 24 June and will continue until 16 Aug., is supported by grants from the National Science Foundation.

Twenty high-school and ten college teachers are preparing the source book under the direction of C. A. Lawson, head of the department of natural science at Michigan State. High-school teachers were selected from 329 applicants, of whom 226 wrote sample exercises and were considered in the final selection.

### NSF Science Faculty Fellowships

The National Science Foundation has announced that applications are being accepted for a second group of science faculty fellowship awards to be made in this calendar year. Closing date for receipt of applications is 3 Sept. The primary purpose of these awards is to provide an opportunity for college and university science teachers to enhance their effectiveness as teachers. Fellowships are offered for study in the mathematical, physical, medical, biological, engineering, and other sciences, including anthropology, psychology, geography, and certain interdisciplinary fields. Approximately 60 fellowship awards will be made on 18 Oct.

Science faculty fellowships are open to any citizen of the United States who holds a baccalaureate degree or its equivalent, has demonstrated ability and special aptitude for science teaching and advanced training, has taught at the collegiate level as a full-time faculty mem-

ber for not less than 3 years, and intends to continue teaching.

Stipends will be individually computed in order to match, as closely as possible, the regular salary of recipients. If a recipient has supplemental support during his tenure, the amount of his award will be reduced accordingly. The foundation's awards will be adjusted so that the combined support—from the foundation and other sources—will not exceed \$10,000 per annum. Additional allowances will be made to assist in defraying costs of travel and certain other expenses associated with the fellowship study. Full tuition will be paid for fellows by the foundation.

Fellows may study at any accredited nonprofit institution of higher education in the United States or similar institution abroad that is approved by the foundation. Fellowships range from 3 to 15 months. Application materials may be obtained from the Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C.

### USPHS Senior Fellowships

The U.S. Public Health Service has announced that applications for senior research fellowships will be received until 1 Sept. Awards will be made on or about 1 Dec. This program is designed to attract and hold able investigators in the basic sciences in the preclinical departments of medical schools, dental schools, and schools of public health. These fellowships are awarded for a period of 5 years and are renewable.

The Public Health Service has not established a stipend for the senior research fellowship; rather, it is intended that the university request an appropriate salary. Information and application blanks should be addressed to the Chief, Research Fellowship Branch, Division of Research Grants, National Institutes of Health, Bethesda 14, Md.

### Proposed Legislation

Of the many bills introduced in Congress, some have a special relevance to science and education. A list of such bills introduced recently follows:

H Con Res 180. Express sense of Congress that Atomic Energy Commission establish an experimental reactor in state of Connecticut. Patterson (R Conn.) Joint Committee on Atomic Energy.

HR 8055. Promote the increase and diffusion of knowledge of polar regions, the Arctic and Antarctic. Bates (R Mass.) House Interior and Insular Affairs.

S 2293. Create a Federal Advisory Council of Health in Executive Office of

the President in accordance with recommendations of Commission on Organization of Executive Branch of the Government, to evaluate and advise on reorganizing economy and to eliminate duplications of efforts and competition among several departments and agencies. Smith (R N.J.) Senate Labor and Public Welfare.

S 2304. Amend Public Health Service Act to provide an emergency 5-year program of grants and scholarships for postgraduate education in field of public health. Humphrey (D Minn.) Senate Labor and Public Works.

HR 8082. Authorize payment of compensation for certain losses suffered as a result of an outbreak of poliomyelitis following the early use of poliomyelitis vaccine. Hillings (R Calif.) House Judiciary.

HR 8112. Protect public health by amending Federal Food, Drug and Cosmetic Act to prohibit use in food of food additives which have not been adequately tested to establish their safety. Miller (R Neb.) House Interstate and Foreign Commerce.

H J Res 364. Provide for the freedom of the mind. Burdick (R N.D.) House Government Operations.

HR 8066. Authorize restoration of times taken from patents covering inventions whose practice was prevented or curtailed during certain emergency periods by service of the patent owner in the Armed Forces or by governmental controls. Hillings (R Calif.) House Judiciary.

### Scientists in the News

THOMAS E. MURRAY, member of the U.S. Atomic Energy Commission, who was not reappointed when his term expired on 30 June [*Science* 125, 1285 (28 June 1957)], has been hired by the Congressional Joint Committee on Atomic Energy to serve as a consultant. Rep. Carl T. Durham (D, N.C.), chairman of the Joint Committee, said the group wanted to utilize Murray's experience "for the advancement of this program and the security of the country," and that his appointment would "ensure that his eminent qualifications will be available to this Nation as it faces the formidable problems of atomic energy that lie ahead."

BRENTON R. LUTZ, former chairman of the department of biology at Boston University, was honored recently at a recognition dinner. He has retired after 43 years of teaching at the university. Speaker for the dinner was Shields Warren, who has been a colleague of Lutz in the field of atomic medicine and cancer research.

EMILIO SEGRE, professor of physics at the University of California, has been awarded the Cannizzaro medal, one of the highest honors of Italian science. This gold medal is conferred internationally every 5 years for outstanding work in science. The selection is made by the Accademia Nazionale dei Lincei (the Italian National Academy of Sciences).

Segre discovered element 43 and was codiscoverer of element 86. He was also a codiscoverer of the fissionability of plutonium. In 1955 he won international attention when he and his colleagues identified the antiproton.

In a special tribute to medicine, the School of Medicine of the University of Turin (Italy) recently conferred honorary medical degrees upon six scientists in different fields: GEORGE DE HEVESY of Stockholm, nuclear medicine; CHARLES B. HUGGINS of Chicago, hormonal treatment of cancer; FRANZ J. KALLMANN of New York, psychiatric genetics; JONAS E. SALK of Pittsburgh, poliomyelitis vaccine; PAUL SANTY of Lyons, cardiovascular (mediastinal) surgery; and ARTHUR STOLL of Monaco, alkaloid chemistry.

Recent appointments to the staff of General Atomic Division of General Dynamics Corporation's John Jay Hopkins Laboratory for Pure and Applied Science, San Diego, Calif., include:

CHARLES C. LOOMIS, a physicist who since 1950 has been a member of the physics staff of Los Alamos Scientific Laboratory;

CHARLES L. OXLEY, who joined the department of physics at the University of Chicago in 1953;

MARK S. NELKIN, research associate at Knolls Atomic Power Laboratory;

BRIAN DUNNE, former head of the shock-wave section of the atomic energy project at the University of California, Los Angeles;

REID D. CARLSON, a member of the analysis staff of the electromagnetic propagation division of Navy Electronics Laboratory, San Diego;

JOHN H. CAWLEY, who since 1949 has worked on electronic instrumentation and data analysis at Scripps Institution of Oceanography, La Jolla, Calif.;

WILLIAM A. COMPTON, chief engineer in the jet division of Thompson Products, Inc.

ROBERT G. FISHER, a senior engineer for Atomics International.

HORACE S. ISBELL, carbohydrate chemist, has been selected to head the organic chemistry section of the National Bureau of Standards. He succeeds W. HAROLD SMITH, who re-



cently retired. Isbell, who joined the Bureau staff in 1927, will direct such work as development of methods for the production of carbon-14 and tritium-labeled materials, stereochemistry, polarimetry, saccharimetry, and utilization of modern physico-chemical principles for rationalization of the reactions of organic substances.

THOMAS J. O'DONNELL of the Central Division Shops of the University of Chicago's Physical Science Division was recently guest of honor at a luncheon in the Quadrangle Club that was attended by more than a hundred of the Chicago faculty and staff. The luncheon marked his reaching the retirement age of 65, but not his actual retirement, for he will continue as a specialist in the Central Division Shops, where he has worked since 1919.

Though he had comparatively little formal education, O'Donnell is an outstanding optical specialist. The devices O'Donnell has created and the problems he has helped solve run into the hundreds. He turned out for Albert A. Michelson the ruling machine that produced interferometer gratings, metal plates with as many as 1500 parallel lines to the inch that broke up light waves and furnished a highly exact means of measurement. In the last decade he has extended the use of this optical method to precision industrial measurements, and many companies are now manufacturing such devices.

The building of the first atomic pile under the west stands of Stagg Field was delayed by the problem of making uranium oxide blocks. The oxide, with no cohesive qualities, could not be contaminated with a binder and fell apart when pressed in ordinary molds. O'Donnell devised a steel die that could be taken apart without jarring and that was so optically polished that the oxide blocks could be removed intact for insertion in the pile.

It was also O'Donnell who created a "scale" used by Chemist Glenn Seaborg to measure the millionth of a gram quantity of the first plutonium produced. He spun quartz into a gossamer filament, measuring by optical means the torsion produced in the filament by the speck of plutonium. The distortion was a measure of the weight. This microbalance was later used by Seaborg in discovering other transuranium elements such as americium and curium.

Before the test bomb was exploded at Alamogordo, the research team needed a roentgen meter much larger than any that had been previously developed; O'Donnell produced it in 10 days.

When there was a delay in completing the 82-inch mirror for the McDonald Observatory of the University of Texas,

which is staffed by the University of Chicago, O'Donnell and his colleague, the late Fred Pearson, took charge. Their methods and supervision completed the job in 2 weeks.

For Raymond E. Zirkle, professor of biophysics, O'Donnell produced two plates of such precision that they could be adjusted within 1 second of arc to permit focussing a beam of radiation on a specific part of a cell, itself only 1/2500 of an inch in diameter.

O'Donnell served in the Navy in World War I, being assigned to optical work on range finders and other devices. After the war the Navy wanted to send him to Vickers, Ltd., England, to continue study on fire-control devices. However, while in the Navy he had worked with Michelson, who suggested that he join the University of Chicago instead.

BENEDICT F. MASSELL, research director of the House of the Good Samaritan, assistant clinical professor at Harvard Medical School, and chief of the Rheumatic Fever Division of the Children's Medical Center in Boston, has received the American Heart Association award of merit in recognition of service in advancing the association's national program to reduce death and disability from diseases of the heart and circulation.

PAUL GYORGY, professor of pediatrics at the University of Pennsylvania School of Medicine, received the sixth Goldberger award in clinical nutrition during the recent annual meeting of the American Medical Association. The award, consisting of a gold medal and \$1000, is presented annually by the AMA Council on Foods and Nutrition, and is provided by the Nutrition Foundation, Inc.

Gyorgy's many significant accomplishments and sustained interest in nutrition are the basis of his selection. He has long recognized the importance of vitamins for the growing body, and is the discoverer of riboflavin, pyridoxine (vitamin B<sub>6</sub>), biotin, and a new microbiological growth factor in milk. Gyorgy also is actively engaged in studying the interrelated problems of protein and amino acid nutrition.

LOUIS J. SOFFER, head of endocrinology at Mount Sinai Hospital and clinical professor of medicine at the State University of New York College of Medicine, has been awarded the university's alumni achievement medal. The citation which goes with the medal reads: "For outstanding contributions to medicine." Last fall he received a similar citation when he was presented with the Harlow Brooks medal of the New York Academy of Medicine.

JAMES R. GILBREATH has been named assistant director of Argonne National Laboratory. He formerly was an executive assistant to Norman Hilberry, laboratory director, and also had served as associate director of the laboratory's chemistry division.

## Recent Deaths

FLOYD J. CARTER, Chevy Chase, Md.; 64; lifetime director of the Maryland State School for the Deaf, formerly president of the New York College of Chiropractic; 19 June.

FRANK A. COWAN, New York, N.Y.; 59; assistant director of operations for Long Lines Department of the American Telephone and Telegraph Company, inventor and leader in the scientific and engineering divisions of the communications field; 23 June.

MAURICE DEUTSCH, Hollywood, Fla.; 73; consulting engineer and president of the Thirty-five Maiden Lane Corporation; coinventor of the seismograph; designed the suspension construction of tracks for Grand Central Station; 20 June.

JOHN DICKSON, New York, N.Y.; 67; chemist and technical consultant; retired technical analyst for the U.S. Rubber Company's textile division, New York City; formerly technical director of A. G. Spalding and Brothers, Chicago, Mass.; 24 June.

HENRY ERIKSON, Miami, Fla.; 87; head of the physics department at the University of Minnesota, 1915-38; author of textbooks on chemistry and physics, including *Elements of Physics*, used in many universities; 22 June.

HENRY GODDARD, Santa Barbara, Calif.; 90; retired professor of abnormal and clinical psychology at Ohio State University, author of *The Kallikak Family*; 19 June.

ALAN GREGG, Big Sur, Calif.; 67; retired vice president of the Rockefeller Foundation, formerly chief of the foundation's medical science division; chairman of AAAS Section N-Medicine in 1949; 19 June.

CHARLES B. KING, Rye, N.Y.; 89; retired automobile manufacturer and engineer-inventor; designed one of the first automobiles and helped Henry Ford construct his first car; 23 June.

VASIL I. KOMAREWSKY, Chicago, Ill.; 62; professor of chemical engineering at the Illinois Institute of Technology; played a prominent role in the development of synthetic fuels; 21 June.

ERNEST L. LITTLE, Columbus, Ohio; 64; president of Research Associates, Columbus, Ohio, and former managing director of the National Farm Chemurgic Council; 23 June.

## Reports

### Radiocarbon Dates from La Venta, Tabasco

We have recently received a series of nine radiocarbon dates of wood charcoal samples, obtained during the 1955 National Geographic Society-Smithsonian Institution-University of California excavations at the site of La Venta, Tabasco, Mexico (1). The radiocarbon determinations were made through the intermediacy of J. B. Griffin at the University Memorial-Phoenix Project Radiocarbon Laboratory, University of Michigan, under the direction of H. R. Crane; costs were defrayed by the National Geographic Society.

La Venta is located about 373 air-line miles southeast of Mexico City in the coastal lowlands near the western border of the state of Tabasco, approximately 12 miles inland from the Gulf of Mexico. This site is the best known major ceremonial center of the classic or florescent phase of the Olmec culture, the exact temporal position of which has long been a subject of controversy. La Venta, with its highly developed stone monumental art and elaborate jade figurines and ornaments, has usually been regarded, especially by archeologists in the United States, as corresponding in time to the earlier part of the classic period of Lowland Maya cultural development. By "the classic period" is usually meant the time-span A.D. 300-900. The present series of carbon-14 dates is in agreement with a growing opinion that the La Venta phase of Olmec culture was in existence for a long time prior to the classic Maya period.

The 1955 excavations at the La Venta site were carried out north of the great

pyramid, principally in the column-enclosed ceremonial court, which Drucker (2, page 9), termed "complex A" in his report on the earlier work at this site. The recent excavations revealed that complex A has a four-phase history—that is, that it underwent three major successive alterations following its initial construction. We have designated these construction phases, from the earliest to latest, by the Roman numerals I, II, III, and IV. We wish to emphasize that these are site construction phases only, not cultural stages; we found no clear evidence of culture change during the time that complex A was in use.

Five samples (Table 1, Nos. M-535, M-529, M-534, M-532, and M-531) were collected from levels which belong stratigraphically to construction phase I. One sample (M-530) came from the phase-II level. Two samples (M-528, M-533) were taken from the lower margin of the 4-foot-thick accumulation of wind-blown sands, which lies directly upon the phase-IV constructions and which, mixed with humus, forms the present surface of the site. These latter samples are referable to post-complex A (post-Olmec?) occupations of the island of La Venta; other evidence for this was encountered during the season. No samples that can be assigned with certainty to the phase-III or phase-IV constructions proper were collected. The maximum time-span covered by the nine samples, within one sigma, is 1580 years (1454 B.C. to A.D. 126). The five phase-I dates span a maximum range of 1150 years, from 1454 B.C. to 304 B.C., again within one sigma. The probability that the five radiocarbon runs from the same stratigraphic phase would show this or a greater maximum date range is 56 out of 100, which is well within the significant range. We feel reasonably sure, therefore, that the average of the five dates ( $2700 \text{ B.P.} \pm 134$ ,  $814 \text{ B.C.} \pm 134$ ) is a close approximation of the actual age of the phase-I constructions at La Venta.

The phase-II sample M-530 gives a date ( $2760 \text{ B.P.} \pm 300$ ,  $804 \text{ B.C.} \pm 300$ ) which is in line with the average for phase I; little more than this can be said about it. Sample M-536 was taken from the lower levels of the base of the great

pyramid, from an excavation of approximately 15 feet into the interior of the pyramid on its northern side. The date almost certainly refers to one of the later stages of construction of the pyramid. The two samples (M-528, M-533) from the lowest level of the drift sand which mantles the site are interpreted as providing an early post-phase-IV date. The arithmetic average of the two dates obtained is 2265 B.P. (309 B.C.); the weighted average, arrived at by the method employed by Wauchope (3), is  $2289 \text{ B.P.} \pm 195$  ( $353 \text{ B.C.} \pm 195$ ). We are unable to determine with accuracy the end of the Olmec phase-IV occupation of complex A, but the average of the two post-phase-IV dates, judged with reference to their stratigraphic position relative to the inferior deposits, enables us to estimate that about a century intervened between the end of the phase-IV occupation and deposition of the charcoal in the basal level of the drift sands. We would place the end of the La Venta phase IV within the period 450-325 B.C., probably near the early part of that period. Complex A thus appears, from the radiocarbon determinations, to have been constructed and used during approximately the four centuries 800 to 400 B.C.

As of this moment, the following observations on the La Venta period of Olmec culture seem justified. Drucker's conclusion (4) that Olmec growth was not dependent on a Maya fountainhead is strongly supported. The carbon-14 dates from La Venta appear to affirm Wauchope's early temporal placement of the La Venta horizon (5). The exact assignment of this period of Olmec culture to a particular stage in current developmental interpretations, such as late formative or early classic, is of course not fully resolved by these dates, but the element of doubt concerning the temporal position of the period is lessened. If the Olmec traits found at the middle preclassic site of Tlatilco in the Valley of Mexico (6) can be definitely associated with the La Venta period, as has been suggested by Drucker (2, page 229), the relatively great time-span of

Table 1. La Venta radiocarbon dates.

Sample No.	Age (yr)	Date, B.C.
M-535	$3110 \pm 300$	$1154 \pm 300$
M-529	$2860 \pm 300$	$904 \pm 300$
M-530	$2760 \pm 300$	$804 \pm 300$
M-534	$2670 \pm 300$	$714 \pm 300$
M-532	$2650 \pm 300$	$694 \pm 300$
M-531	$2560 \pm 300$	$604 \pm 300$
M-536	$2530 \pm 300$	$574 \pm 300$
M-528	$2400 \pm 250$	$444 \pm 250$
M-533	$2130 \pm 300$	$174 \pm 300$

All technical papers and comments on them are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table or one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).



this period and its nonconformity to currently proposed views of Mesoamerican culture development (3, 7) will be clear. The difficulty of accepting certain sculptured pieces from the Olmec area which bear initial series inscriptions—such as the Tuxtla statuette and stela C from Tres Zapotes—on the grounds of the improbably early dates indicated (8) would appear to be greatly diminished. The final report on the 1955 excavations at La Venta is nearing completion and will be published by the Bureau of American Ethnology.

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ROBERT F. HEIZER

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15 April 1957

### Probable Cause of Necrotic Spider Bite in the Midwest

Current medical references used by practising physicians list the black widow, *Latrodectus mactans*, and other species of *Latrodectus* as the only spiders occurring in the United States that may inflict bites serious enough to require medical treatment. Physicians practising in rural areas in the Midwest have realized for some time that other species occasionally bite and cause conditions, which, though less generally severe than those occasioned by the bite of *L. mactans*, are serious enough to require attention. In some cases the animal inflicting the bite has not been observed by the patient, and the attending physician has attributed the condition to "insect bite."

With the exception of certain species of Reduviidae, there are no midwestern Hexapoda known to inflict severe injury by bite to human beings. According to Herms (1) reduviid bites are characterized by intense local pain, swelling, intense itching, and, in a few cases, profuse urticaria over the body and a local cellulitis followed by necrosis in the immedi-

ate vicinity of the bite. In a few days the symptoms resulting from reduviid bite are usually gone.

Several clinical cases of spider bite in Missouri by a "brown spider" are available. Usually, the spider became entangled in the patient's clothing and bit when it was crushed or removed. First symptoms varied, presumably with the relative amount of venom injected, but a thick wheal usually forms with necrosis of tissues at the immediate site of the punctures made by the chelicerae. The necrotic area soon turns violaceous, then black and dry. This area sloughs in a few days or a week, leaving a deep, sharply-defined granular area surrounded by the raised edges of healthy tissue. The sloughed area, frequently quite large, may persist for several weeks, and healing takes place very slowly. In a few patients, systemic disturbance of a general nature has been indicated by a rash resembling that of scarlet fever.

In these cases, spiders inflicting such necrotizing venom have not been available for identification. In a single case a specimen of *Loxosceles reclusus* Gertsch and Mulaik has been circumstantially incriminated.

A striking similarity between these necrotic, spider-inflicted wounds in Missouri and the "gangrenous spot" or cutaneous arachnoidism of Chile, Uruguay, and other South American countries is evident. Macchiavello (2) first indicated *Loxosceles laeta* (Nicolet) as the causative agent of such gangrenous spot on human beings in Chile as early as 1937. Subsequent experimentation with the glandular poison of *L. laeta* by Macchiavello (3) and by MacKinnon and Witkind (4) has established firmly the role of *L. laeta* in cutaneous arachnoidism in South America. Symptoms in patients bitten by *L. laeta* are similar to those in patients observed in Missouri.

Since *Loxosceles reclusus* was circumstantially incriminated in human necrosis before the South American literature was reviewed, and since it belongs in the same genus, it is not unduly presumptive tentatively to assign to *L. reclusus* the same relationship with cutaneous arachnoidism in Missouri that *L. laeta* bears to that condition in South America. Experiments are currently underway involving *Loxosceles reclusus* and laboratory animals. Preliminary results indicate that the venom of *L. reclusus* is a powerful necrotizing agent capable of causing cutaneous necrosis in mammals.

Gertsch (5), in discussing spider venoms, states that the venom of a few spiders is fortified with toxins that cause severe local or general reactions. He reports that some venoms contain hematoxins that destroy cells in the vicinity of the wound and result in extensive

sloughing and exposure of underlying tissues. *Loxosceles laeta* is the proved agent causing such conditions in South America. *Loxosceles reclusus* is probably responsible for the same conditions in the southern and southwestern United States as well as in the Midwest (6).

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6. A description of the results of experiments with *Loxosceles reclusus* venom and laboratory animals, together with complete documentation of human medical cases, is in preparation.

\* Deceased December 1956.

27 March 1957

### Influence of Prenatal Maternal Anxiety on Emotionality in Young Rats

W. R. Thompson [*Science* 125, 698 (1957)] has reported results which are compatible with the hypothesis that "prenatal maternal anxiety does actually increase the emotionality of offspring." Five female rats were trained "first to expect strong shock at the sound of a buzzer, and then to avoid the shock by opening a door between the compartments and running through to the safe side." These rats, as well as a group of five control rats, were then mated.

During gestation, the experimental mothers were "exposed to the buzzer three times every day in the shock side of the shuttlebox, but with the shock turned off and the door to the safe side locked." The offspring of the experimental and control mothers were tested for differences in "emotionality," and the observed differences were traced to the stress situations which were imposed on the experimental mothers during gestation.

It is possible, however, that differences in prenatal environment may have resulted from maternal hormonal differences caused by systemic changes which were produced in response to the stress

of the training period. This variable could be controlled by subjecting the control mothers to the same training and premating stress as the experimental mothers.

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17 April 1957

I am grateful to A. R. Kaplan for pointing out a possible interpretation of my experimental results on prenatal influences [*Science* 125, 698 (1957)] that I had been quite aware of but had neglected to indicate in the published article. I am now starting a project to examine this question thoroughly.

How such effects, if they really occur, have their action cannot be answered at present. But I would suggest that a mother stressed before pregnancy would tend to have a much lower threshold of reactivity to any of the mild stresses that may occur during the course of normal laboratory life. Thus, radically altering the mother before pregnancy may be quite equivalent to radically altering the environment during pregnancy.

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1 May 1957

## Electroencephalographic

### "Blocking" and "Adaptation"

Under the title "EEG, consciousness, and sleep," Simon and Emmons (1) have presented evidence that conditions of wakefulness favorable to recognition and recall of stimuli are accompanied or preceded within 30 seconds by recordable alpha rhythm. Yet the authors recognize that processes of attention or concentration following stimulation tend to be simultaneous with reduction or "blocking" of the alpha rhythm.

Although the electroencephalogram is a record, from outside the head, of electric activity in the underlying cortex, the magnitude of this activity depends to a very large extent on the effectiveness of subcortical pacemakers in driving and synchronizing the cortical cellular activity (2). It follows that the blocking of alpha by stimulation can be easily explained if it is assumed that, during reaction, the cortical cells engage in independent, nonsynchronous activity (3). However, recent evidence shows that, at least in the case of peripheral stimuli, blocking or "activation" of the cortex may be the result of asynchronous subcortical impulses to the cortex from the brain stem reticular formation (4).

Whether this latter explanation applies equally to blocking by perceptual and ideational stimuli, which depend for effectiveness on cortical or cortico-thalamic integrative and interpretative processes, may still be a question.

Particularly significant is the fact that blocking occurs in response to any new stimulus that calls for interpretation or readjustment but disappears as the stimulus is evaluated and adjusted to. An example of decreased blocking by successive loud gong stimuli at 10-second intervals is presented in Fig. 1. Measurements of the "percent time alpha" (5) of 20 left occipital electroencephalographic records were obtained by conventional methods. The percentage of time occupied by sequences of three or more 8- to 12-per-second waves of more than 15  $\mu$ v amplitude was determined for the 3 seconds before and the 3 seconds after each gong stimulus. The mean effects of nine successive repetitions for 20 subjects show a progressive reduction of blocking. The decrease of blocking from gong 1 to gong 6 is 16.02 percent, and from gong 1 to gong 9 is 28.12 percent. The probability of this decrease occurring by chance is less than 5 in 100 at gong 6 and less than 1 in 100 at gong 9.

Phase relationships of waves in different head areas had previously shown reliable adaptation of response to successive gong stimuli, and the palmar galvanic responses were likewise reliably reduced with repetition (6). We have also found that, with eyes closed, repeated writing of a word on an imaginary blackboard produces marked initial blocking, especially in the left hemisphere, and a decrease or elimination of blocking with practice. In fact, any novel stimulus or activity will tend, at first, to be accompanied by blocking of the alpha rhythm, and, with familiarity, habituation, solution of the problem, or

rendering of the activity automatic, alpha will be restored.

Similar observations of blocking of the alpha rhythm are to be found throughout the literature on the electroencephalogram. Their import, however, is not always made explicit. That blocking occurs during periods of attention, adjustment, and problem solving, when cortical integrative processes are going on, and that alpha returns with "automation" as other mechanisms, presumably subcortical, become competent to carry on and free the cortex for new problems deserve consideration. As is possibly evident in Simon and Emmons' observation of the waking resting state, alpha may then prevail, and the cortex will ride the wave of mental operations as monitor—to intervene only when things in some department fail to run smoothly.

The possibility of a shift from blocking to alpha activity with repetition, from active integration to automation, and from, presumably, cortical to subcortical control with habituation accounts likewise for many puzzling observations. It explains, for example, the fact noted by Hebb (7) and others that complex test behaviors involving learned skills which are probably relegated to subcortical control may be relatively little disturbed by extensive cortical damage. It explains how complex psychomotor behaviors, which were once cortically determined, may sometimes become inaccessible and uncontrolled when routinized under automatic subcortical control. It explains Simon and Emmons' observation of a relatively high incidence of waking alpha during learning of repeated stimuli, notwithstanding the blocking effects usually associated with processes of attention or "concentration."

If the afore-noted electroencephalographic indications of the shifting levels

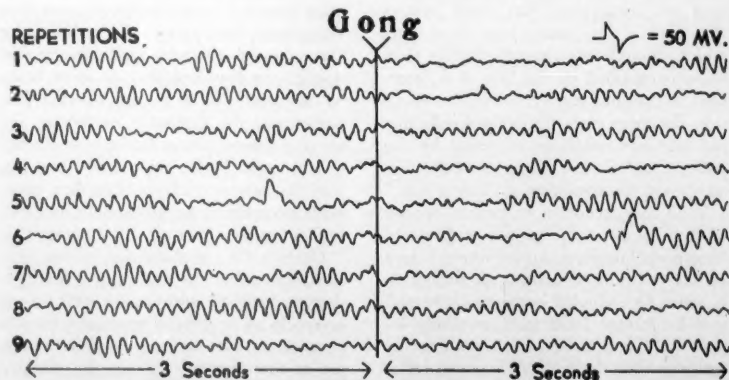


Fig. 1. Example of decreased alpha "blocking" with repetition. Gong at 10-second intervals. Paper speed, 5 cm/sec calibration is 50  $\mu$ v.

of relative cortical-subcortical function are valid, they present far-reaching implications for the interpretation of cerebral function.

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4 April 1957

### Differential Excretion of D-Phenylalanine in Man

In the course of an investigation into the extent of genetic control over certain aspects of phenylalanine metabolism in man, a major discrepancy was noted between the results of two methods used in determining urinary phenylalanine after ingestion of the L form of this amino acid. The two methods were one-dimensional paper chromatography, in which a butanol-acetic acid-water mixture was used, and a modified form of the decarboxylase method of Udenfriend and Cooper (1). The paper chromatographic results were markedly higher than the decarboxylase values and were well beyond any methodologic differences. Since the decarboxylase method is specific for L-phenylalanine, while chromatographic techniques do not distinguish between the L and D forms, the simplest explanation of these results was that the ingested phenylalanine was racemic. Consequently, tests were run to examine this hypothesis, and they clearly demonstrated that the original substrate was slightly racemic. The purpose of this report is to point out the possibility and implications of minor isomeric contamination in studies of amino acid metabolism and to consider the interesting variation in excretion rate of D-phenylalanine that was observed among individuals in these experiments (2).

Meister et al. (3) have discussed the problem of determining the degree of optical purity of various amino acids. They point out that techniques such as

polarimetry cannot detect isomeric impurities of less than 1.00 mg percent, while the use of oxidases and decarboxylases in properly designed Warburg experiments can detect isomeric contamination of less than 0.10 mg percent. In this work, the presence of D-phenylalanine was demonstrated by measuring the oxygen uptake on incubation with D-amino acid oxidase, according to Burton (4). The original sample of phenylalanine was run in the Warburg apparatus with known amounts of D-phenylalanine as controls, and oxygen uptake occurred equivalent to 0.60 mg percent of D-phenylalanine. A second sample of L-phenylalanine from a different source, but not used in these metabolic experiments, was tested in a similar manner and was found to contain 0.17 mg percent of D-phenylalanine.

For most biochemical and physiological experiments, such minor impurities would probably be undetectable. However, in studies that involve recovery of ingested amino acids from the urine, isomeric contamination of the order of 0.10 mg percent could lead to serious error. This follows from the fact that the kidney acts as a highly selective filter, retaining most L-amino acids with an efficiency of more than 95 percent, while the D forms are excreted quite readily (5, 6).

In the present studies, 2 g of the L-phenylalanine, estimated to contain 0.60 mg percent of the D-isomer, was given orally, and urine was collected for the following hour. The phenylalanine concentration in the urine samples was determined by the decarboxylase and paper chromatographic methods, the difference between the two being taken

as an estimate of the concentration of D-phenylalanine in the specimens. The percentage of the D-isomer in these specimens averaged more than 50 percent. With feedings of from 5 to 10 g of the substrate, isomeric contamination of as little as 0.10 mg percent could lead to an error of the same order of magnitude.

The simplest way to avoid the problem of minor isomeric contamination would be to utilize techniques that are specific for the L form of the amino acid, such as the enzymic, and most microbiological methods. Another approach would be to use the assays suggested by Meister et al. (3) to insure minimal isomeric contamination. In this connection we should like to suggest the possibility of using man as a concentrating mechanism for a suspected racemic amino acid mixture before assaying it for D contamination. Such a system could increase by 100-fold the sensitivity of detection of isomeric contamination.

In Table 1 are given the data on the excretion rate of D-phenylalanine after the ingestion of 2 g of the racemic phenylalanine, containing 0.60 mg percent of the D-isomer. The data are reported as milligrams of D-phenylalanine per milligrams of creatinine and represent the average concentration for the first hour's urine specimen following the feeding. The experimental subjects were normal monozygotic and like-sexed dizygotic twins.

As can be seen, there is considerable variation in the excretion rate of D-phenylalanine, the range being more than 15-fold (0.024-0.379). Variability in the excretion rate of D-isomers, and in particular of D-phenylalanine, has been observed before (5, 7). The physiologic ex-

Table 1. Urinary excretion rate of D-phenylalanine in monozygotic and dizygotic twins.

Twins	Sex	Ratio of D-phenylalanine to creatinine (mg/mg)	Intrapair differences	Mean intrapair difference
<i>Monozygotic</i>				
1 A	♀	0.086	0.020	0.025
B		0.106		
2 A	♀	0.091	0.026	
B		0.117		
3 A	♂	0.052	0.028	
B		0.024		
<i>Dizygotic</i>				
4 A	♀	0.074	0.036	0.058
B		0.110		
5 A	♀	0.035	0.017	
B		0.052		
6 A	♀	0.144	0.060	
B		0.084		
7 A	♀	0.205	0.174	11.7*
B		0.379		
8 A	♂	0.025	0.004	
B		0.029		
Intrapair variance ratio, dizygotics/monozygotics				

\* Significant beyond the 0.05 level.



planation of this variation in excretion rate is far from clear, although several possibilities, such as variations in kidney D-amino acid oxidase activity and renal readorption mechanisms, have been discussed (5, 8). Because of the low levels of D-phenylalanine in this work, it was not possible to examine any of these physiologic hypotheses.

What is of most interest to us is the genetic information that can be obtained from a comparison of the intrapair differences and variances in excretion rates between the pairs of monozygotic and dizygotic twins. As can be seen in Table 1, the average intrapair difference for the dizygotic twin pairs is more than twice as large as that for the monozygotic pairs. The intrapair variance ratio for the dizygotic/monozygotic is 11.7, which, with 5 and 3 degrees of freedom, is significant at higher than the 5 percent level. This would mean that at least part of the observed variation in excretion rate of D-phenylalanine is the result of genetic differences. The work of Goodman (8) on mice is particularly relevant here, since she also found evidence for genetic control of variation in excretion rates of the D-isomers of several amino acids, including phenylalanine. It would appear that further work on the physiology and genetics of differential excretion of the D-isomers would be very rewarding.

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#### Glia/Nerve Cell Index for Cortex of the Whale

Since man occupies the top position in the phylogenetic scale and has attained the highest intellectual development, there has been a well-understood tendency to relate certain characteristics of the morphology of his brain to this development. Early attempts to parallel intellectual performance with brain weight, relationship of brain weight to body weight, and number of convolu-

tions now have only historical interest. Certain aspects of the histology of the cerebral cortex were also thought to reflect phylogenetic development. The idea that the more highly developed cortex contains more "space" between nerve cells probably was expressed first by Nissl (1) and was later supported by such an authority on cerebral cytology as Economo (2). More recently, Friede (3) studied the glia index (number of glia cells per nerve cell) in the cortex of various animals and found that it increases from the frog to man. He concluded that the ascending phylogenetic development of the cortex is characterized by a relative increase in glia cells.

However, the human brain is not only the most highly developed but it is also the largest brain that is usually studied. It is possible, therefore, that certain histological characteristics of the cerebral cortex may reflect an increase in size and not in the phylogenetic development. Thus, Tower (4), studying the cell density of the cerebral cortex, included in his series the brain of the whale and elephant, which are the only two animals with a brain weight higher than that of man. He found that the cortical cell density was inversely correlated with brain weight, and not with the position of the animal on the phylogenetic scale.

It is the purpose of this report to show that the glia/nerve cell index reflects brain weight rather than phylogenetic development. Our histological material was a portion of that used by Tower (4, 5) and consisted of 20-μ paraffin sections of two whale (*Balaenoptera physalus* L.) brains which weighed 6500 g and 7150 g, respectively. Cortex from three sections, two from the frontal region and one from the occipital region, was studied. A 20-μ paraffin section of the temporal cortex of a 36-year-old woman was also examined for the purpose of the comparison of our results with those of Friede (3).

Photomicrographs at a magnification of 80 were made, and the glia cells and nerve cells were marked on them with the aid of direct microscopic observation of the slides. No attempt was made to differentiate between the types of glia cells, but care was taken to avoid marking endothelial nuclei. The marked cells were counted according to the following rules. In the whale cortex, the counts were made separately only for layer II; the deeper layers were counted together. Separate counts for nerve cells containing or not containing nucleoli were made. In the human cortex, layers II to IV were counted separately, layers V and VI together. All nerve cells were counted, irrespective of whether or not they contained nucleoli. Data are recorded in Table 1.

As can be seen from Table 1, the glia/

Table 1. Number of glia and nerve cells counted and the glia/nerve cell index for whale and man.

Layer	Cells counted		Glia/ nerve cell index
	Glia	Nerve	
<i>Whale, specimen No. Cst-1</i>			
II	185	167	1.11
III to VI	2116	473	4.47
All	2301	640	3.59
<i>Whale, specimen No. C-293</i>			
II	277	150	1.84
III to VI	1717	264	6.50
All	1994	414	4.81
<i>Whale, specimen No. C-293</i>			
II	290	186	1.56
III to VI	2454	311	7.89
All	2744	497	5.52
<i>Whale (total)</i>			
	7039	1551	4.54
<i>Man</i>			
II	714	468	1.53
III	627	343	1.83
IV	870	424	2.06
V and VI	657	371	1.27
<i>Man (total)</i>			
	2868	1606	1.78

nerve cell index of the cerebral cortex is much higher in the whale than in man. The value for the human cortex is 1.78, which is very close to the ratio of 1.68 established by Friede. Our index was obtained by investigation of only one region in the first temporal convolution. Because of the agreement of our value with that of Friede, we did not investigate other regions. In the whale, we studied three regions, two from one animal and one from the other. Though the ratio varied from 3.59 to 5.52, it was significantly higher than in man, the average for all three regions being 4.54. Statistical analysis of these results was made, applying the formula

$$t = \frac{x - y}{\sqrt{\frac{x(1-x)}{N_1} + \frac{y(1-y)}{N_2}}}$$

and the results were found to be highly significant.

These values for the whale were obtained when all nerve cells, whether they contained nucleoli or not, were counted. By applying such a method, we incurred an error resulting from the fact that when particles are counted in histological sections, the true number per volume is smaller than that counted (6). This error increases with the increase of the ratio between the size of the particles and the thickness of sections. Since the nerve cells of the whale are larger than those of man, and since all our sections were 20 μ thick, we overestimated the number of nerve cells for the whale cor-



tex to a slightly greater extent than we did for the human cortex. Therefore, the actual difference between the indices should be even higher than that given. In order to find out the size of the error with which we were dealing, we also counted in the whale only such nerve cells as contained nucleoli. The glia/nerve cell index obtained in this manner was 5.86.

It is interesting to note that the index for the whale was consistently lower in the second cortical layer. This layer is also more cellular than the rest of the cortex, and it is possible that these two characteristics are correlated. The differences between the indices of the three regions of the whale cortex may represent consistent regional variations, or be only an accidental finding. This problem requires further investigation. We did not intend to establish absolute values, but only to compare the index for man with that for the whale.

Thus our results indicate that the increase in the number of glia cells per nerve cell is not correlated with the phylogenetic development, but with brain size. The significance of this increase is not known, but it may be suggested that it is related to the increase in the size of the nerve cells, which have longer processes and require more assistance from the supportive tissue to meet their metabolic needs. It may be of great interest for the understanding of the physiology of glia cells to determine whether one particular type of glia cell is involved in this increase.

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1 April 1957

### Lack of Congenital Malformations in Normal Human Pregnancies after Transabdominal Amniocentesis

Recently considerable interest has been shown in studying human amniotic fluid. There are many references scattered throughout the literature which suggest that analysis of amniotic fluid may be of diagnostic value. Amniotic fluid may be considered as an additional body fluid compartment in the pregnant mother. Theoretically, amniotic fluid should reflect physiologic and pathologic condi-

Table 1. Experience with transabdominal amniocentesis in 50 normal patients.

Gestation (wk)	Patients (No.)	Taps	
		Successful	Unsuccessful
20-24	5	5	0
24-28	8	8	0
28-32	13	12	1
32-36	13	11	2
36-40	11	10	1
Total	50	46	4

tions of the fetus or maternal host, or both, just as whole blood, plasma, urine, and cerebrospinal fluid indicate pathologic conditions in the nonpregnant host.

One reason amniotic fluid has not been studied extensively throughout various stages of gestation in human beings is that most physicians and investigators do not realize how easily and safely it can be obtained. Rivett (1) discussed the theoretical complications of transabdominal amniocentesis in human beings. More recently, Trasler and her associates (2) reported experimental evidence of congenital malformations in mice following puncture of the amniotic sac. They suggested that the procedure may produce similar congenital malformations in human beings.

The purpose of this report is to describe our results with 50 transabdominal amniocenteses in normal human beings during the last two trimesters of pregnancy. An 18-gauge spinal needle with a trocar was used for these tests. From 15 to 25 ml of fluid was withdrawn when possible. Table 1 lists the patients by weeks of gestation and indicates the results obtained. There were 46 successful and four unsuccessful taps. The only maternal complications immediately following amniocentesis were two patients who developed infections of the urinary tract. We attribute these to faulty sterile technique in preoperative catheterization. None of the patients had premature labor precipitated by the procedure. All of the abdominal wounds healed without infection.

Each mother was followed during her prenatal course, delivery, and postnatal course. The placenta and fetus were carefully examined for evidence of trauma or other abnormalities which might have resulted from puncture of the amniotic sac. All the placentas appeared normal. The infants were all perfectly formed and were without external signs of congenital malformations. No evidence of fetal trauma was found.

The only complication was one primigravida who developed acute preeclampsia 5 weeks after amniocentesis. She experienced a complete placental separation during the thirty-fourth week of

pregnancy, and the infant was stillborn. The stillborn infant had no anatomic abnormalities or evidences of trauma. Because this complication occurred such a long time after transabdominal amniocentesis, we do not feel that the procedure was a causative factor.

In our experience, transabdominal amniocentesis is a safe and easy way to obtain amniotic fluid in normal human beings during the last two trimesters of pregnancy. There was no evidence of maternal or fetal trauma. In contrast to the high incidence of congenital malformations produced by amniotomy in mice, we found no congenital malformations in human beings following transabdominal amniocentesis. Perhaps these differences are related to the stage of pregnancy when amniocentesis is performed and the ratio of fetal volume to amniotic fluid volume in various species.

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### Monitoring of Low-Frequency Phenomena

Many physical phenomena occur at frequencies which are generally so low that they require visual attention during monitoring or recording. Whether such phenomena are detected through their concomitant electric activity [for example, electric activity of the heart (ECG) or brain (EEG)] or through the use of electric transducers (for example, for measuring blood pressure or other fluctuating pressures), audio monitoring frees the visual attention of the experimenter for the observation of other phenomena or for the performance of other tasks. The experimenter is given a constant indication of the experiment and may be confident that he will hear any changes as soon as they happen.

A transistor regenerative oscillator was adapted from an experimental model (1) to convert subaudible frequencies into audio frequencies. Other transistor oscillators have been described (2) which could be similarly adapted. The frequency of oscillation of the oscillator varies inversely with the supply voltage.

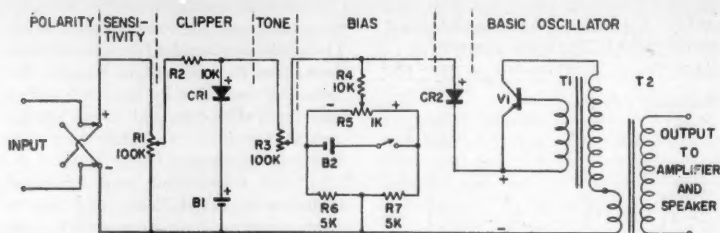


Fig. 1. Schematic diagram of frequency-modulated oscillator: K, 1000 ohms; CR1 and CR2, 1N56 high-conduction germanium diodes; V1, CK 722 p-n-p junction transistor; T1, 1/3 interstage transformer; T2, microphone transformer; B1 and B2, 1.4-v battery.

Furthermore, the power requirements are so low (a 50- $\mu$ w input gives a 400-cy/sec tone) that the oscillator may be powered directly by the electric signal. Thus, amplitude variations of an otherwise inaudible signal, whether they are periodic or random in nature or even slow changes in a steady level, are translated into tonal variations. The audio-frequency tones produced may be, with experience, of great diagnostic or interpretive value. However, the device was designed as a monitor, since visual patterns are usually easier to study and interpret.

The monitor was designed to be connected across the coils of a recording galvanometer (for example, an electroencephalograph or electrocardiograph) but can be used with any other source providing more than 0.5-v input to the monitor. The output can be fed into a loudspeaker system or high-impedance earphones. The device is simple, self-contained, reliable, and inexpensive (about \$10 for parts). More elaborate, but less versatile, heart monitors have been available commercially (3).

The basic oscillator gives an 1800-cy/sec tone at 0.2-v input, a 200 cy/sec tone at 0.75-v input, and a 50-cy/sec tone

at 2-v input. Below about 400-cy/sec, the tone is more in the nature of a pulse than the sine wave found at higher frequencies. The load on transformer T2 (Fig. 1) affects the quality of the tone. Polarity is important. If no oscillations are produced when about 1.0 v is applied to the basic oscillator, the leads of the secondary of transformer T1 should be reversed. The diodes and transistor are damaged by heat, so the leads should be kept long, and a hemostat or pair of pliers should be used as a heat sink when soldering.

Several refinements were added. (i) A sensitivity control, R1, regulates the input voltage required for a given tone. At maximum sensitivity, 0.5 v gives an 1800-cy/sec tone, whereas 5 v are needed at mid-range, and more than 100 v at nearly zero sensitivity. (ii) A clipping circuit consisting of a 1.4-v mercury battery and a crystal diode, CR1, was added to give the device a roughly logarithmic response. This prevents the suppression of low-level components in a signal with a wide dynamic range. As an example, the QRS component of the electrocardiograph (Fig. 2) has a much higher amplitude than the P and T waves, and thus tends to overpower their tone. The T wave, however, is of particular interest because changes in amplitude or polarity indicate anoxia or heart damage. When the series resistances from R1 plus R2 and from R3 are both greater than 20,000 ohms, the signal going to the oscillator is sharply limited to about 1.4 v. (iii) Variable resistor R3 acts as a tone control for the clipped segments, such as the QRS. Thus, 1.4 v coming from the "clipper" can be set to give a tone from 300 to 2000 cy/sec. (iv) The bias network, R4 through R7 and B2, acts to suppress noise or the effects of power-amplifier imbalance by adding a negative voltage which the signal must overcome to energize the oscillator. By setting it to give a positive voltage, a steady baseline tone is produced which may then be frequency modulated by the signal. A switch is needed on B2 because of the low resistance load, whereas diode CR1 acts as

an effective switch for B1. (v) The diode, CR2, rectifies the signal since the oscillator operates only with the polarity indicated (and may be damaged by currents of opposite polarity). For instance, an inverted T wave of an electrocardiogram causes a lack of tone when the bias control is set in the neutral position. A polarity reversing switch in the input circuit is a helpful addition. (vi) The transformer T2 is used to increase the amplitude of oscillator output signal and also to isolate the monitor from the speaker system, since the galvanometers of many direct-writing oscillographs are not at ground potential. Figure 2 shows how this device treats a complex input waveform by converting it to bursts of audio frequencies of different tones and amplitudes.

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29 April 1957

### Boron in Morphogenesis of Plant Cell Walls

An intensive study of cell walls in celery (*Apium graveolens* L., var. *dulce* Pers.) grown under different boron levels was undertaken because of the widely recognized effects of boron nutrition on carbohydrate metabolism in plants (1). In addition, the extensive literature on boron nutrition includes very little information on cell-wall structure. A large body of evidence shows that, under boron deficiency, carbohydrates accumulate in the plant and in some cases new carbohydrates may be formed (2). There is also evidence that boron facilitates the translocation of carbohydrates in the plant (3, 4), although a recent report (5) does not support this conclusively.

Three varieties of celery were grown in Hoagland and Arnon's solution 2 (6) with boron levels modified to range from 0.50 ppm (normal) to 0.00 ppm. Analyses showed that the boron content of the celery was markedly changed by the treatments. The boron content (dry-weight basis) of the petioles of Dwarf Golden Self Blanching, for example, was 36 ppm when the plants were grown at 0.50 ppm and 13 ppm when they were grown at 0.01 ppm. Measurements of cell-wall thickness and observations on

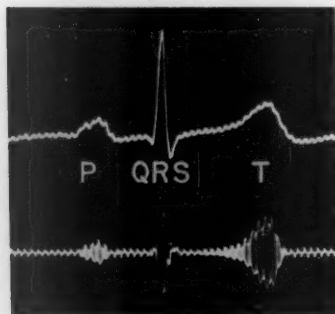


Fig. 2. Oscilloscope tracing of normal human electrocardiogram (top) with output from the audio monitor (bottom). The P wave gave a high-frequency tone followed by the QRS complex, which gave a short, low-pitched tone. The T wave gave a softer, medium-pitched, prolonged tone.

Table 1. Collenchyma cell-wall thickness as affected by the boron supply in the nutrient solution in three varieties of celery.

Variety	Wall thickness ( $\mu$ ) at contrasting levels of boron	
	0.50 ppm (normal)	0.00 ppm (deficient)
Dwarf Golden		
Self Blanching	8.2	2.8
Utah 15	8.0	2.3
Utah 10-B	9.4	4.1

the fine structure were made on sections 2 or 3  $\mu$  thick from material imbedded in a water-soluble medium (polyethylene glycol). After the sections had been stained, an aqueous mounting medium (7), slightly modified from the previous formula, was used in preparing slides. These histological methods, especially for parenchymatous tissues, avoid the cell-wall shrinkage caused by the paraffin techniques. A polarizing microscope and microchemical and solubility tests were used in the study of cell-wall constituents. This study was restricted to material collected from the mid-level of petioles that were estimated to have just completed length growth. Thus, observations were made on mature petioles that had grown under various levels of boron supply during their major period of development. Observations were further restricted to three tissues: (i) the collenchyma immediately under the epidermis of the ribs on the abaxial side; (ii) the larger, more peripheral elements of the phloem parenchyma in the bundle cap; and (iii) the ground parenchyma.

At a normal level of boron nutrition (0.50 ppm), the thicker portions of the common wall between two collenchyma cells in all three varieties of celery are about 8 to 9  $\mu$  thick. Under extreme boron deficiency (0.00 ppm), however, the thicker portions of the walls of most collenchyma cells are only about 2 to

4  $\mu$  thick (Table 1; note extreme right portions of Fig. 1). The effect is more or less directly proportional to the boron supply.

In the phloem parenchyma of all three varieties, the cell walls become much thicker under boron deficiency. At 0.50 ppm, the common walls between cells are about 1.0  $\mu$  thick, whereas at 0.00 ppm the walls range from about 2 to 3.5  $\mu$  thick (Table 2). This response is more or less inversely proportional to the boron supply. Similar striking changes in cell-wall thickness occur in the ground parenchyma. The effect on these two tissues is in marked contrast to the response shown by most of the collenchyma cells. The level of boron in the plant apparently affects the rate of carbohydrate condensation into wall material.

Some collenchyma cells in two of the varieties (Dwarf Golden Self Blanching and Utah 10-B) exhibit a very special response to boron deficiency. The cells that are affected are located at the periphery of the collenchyma strands, although more deeply situated cells in the strands may also show the response. Whereas normal collenchyma cells are characteristically thickened at the "corners" (that is, at the three- or four-rayed vertices of the contacting walls), the specially affected cells have a massive, uniformly thick inner band of wall material (Fig. 1). This is a very basic change in the way the cell wall is laid down. The thickening phenomenon in the specially affected collenchyma cells appears to be similar to that occurring in the adjacent ground parenchyma and the phloem parenchyma, except that the thickening in the latter two tissues is not as great.

In normal material the walls are very fine-grained. The cells walls of boron-deficient tissues, however, are much coarser (Fig. 1). Measurements of the light- and dark-staining lamellae in the unswollen walls of the collenchyma of all three varieties showed that in normal collenchyma the lamellae are about 0.30  $\mu$  thick, whereas in boron-deficient material their width is about 0.20  $\mu$ . Counts were made of the number of lamellae in collenchyma cell walls swollen by microchemical treatments. Normal collenchyma contains about 60 light- and dark-staining lamellae, whereas boron-deficient collenchyma has about 20. These differences in the fine structure of the walls suggest that boron affects the process of carbohydrate condensation into wall material.

The response of most of the collenchyma to a low boron supply suggests that its walls fail to thicken because of a deficiency of carbohydrates. Since the ground parenchyma and phloem parenchyma in the same sections become much thicker walled, it appears that

carbohydrates from the major source, the phloem, are condensed in these intervening tissues before they reach the more peripheral collenchyma. If this interpretation is correct, the histological evidence presented here supports the hypothesis of Gauch and Dugger (3) that boron facilitates the translocation of carbohydrates in the plant.

Frequent comments occur in the literature (8) that mineral nutrition affects the development of the form of the plant—that is, its morphogenesis. This view is based in part on the fact that a number of mineral elements or conditions are reported to affect the walls. Though little detailed information is available on the relationship of mineral nutrition to cell-wall differentiation, the work of Schneider (9) provides an example of

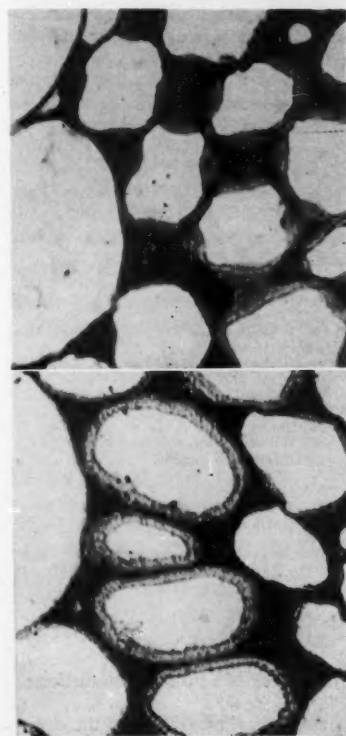


Fig. 1. Transverse sections of celery petioles showing normal and boron-deficient collenchyma tissue near the margins of collenchyma strands in the variety Dwarf Golden Self Blanching. Portions of ground parenchyma cells are on the left side of the photographs. (Top) Normal tissue grown at 0.50 ppm B, showing characteristic collenchyma wall thickenings mainly at the "corners" of the cells. (Bottom) Affected tissue grown at 0.00 ppm B, showing the reduced thickness of the walls in right portion of the photograph and the marked difference in the organization of the walls in the cells at the margin of the strand.  $\times 730$ .

Table 2. Phloem parenchyma cell-wall thickness as affected by the boron supply in the nutrient solution in three varieties of celery.

Variety	Wall thickness ( $\mu$ ) at contrasting levels of boron	
	0.50 ppm (normal)	0.00 ppm (deficient)
Dwarf Golden		
Self Blanching	1.0	3.5
Utah 15	0.81	2.2
Utah 10-B	1.2	2.4



studies in which this subject is considered. Other agents besides minerals are involved in cell-wall differentiation. Jacobs (10), for example, has recently concluded that auxin is a limiting factor in the differentiation of xylem cells. Our evidence suggests that boron is one morphogenetic agent affecting the differentiation of cell walls. How this action may be mediated by boron is not understood. A close involvement of boron in cell-wall differentiation, however, is suggested by the fact that it very likely complexes with a number of polyhydroxy compounds in the plant, such as various sugars and pectic materials (11), which become part of the cell-wall substance.

Intensive studies of the cell walls in relation to boron nutrition show that the normal pattern of cell-wall differentiation is profoundly changed by boron deficiency. This fact and the relationship of boron to carbohydrate metabolism implicate boron as an agent in the morphogenesis of plant cell walls (12).

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25 April 1957

### Amino Acids in Fossil Human Bone

In a recent investigation of the chemical constituents of fossil human bone conducted in our laboratory, it was observed (1, 2) that bones of great archeological age may contain appreciable quantities of organic nitrogen. The significance of these findings for dating prehistoric bone has been discussed elsewhere (2, 3). It is highly probable that the source of this nitrogen is the original proteins, as suggested by Abelson (4). If so, a question of interest is: How many of the constituent amino acids are able to retain their chemical individuality under the conditions attending archeological preservation.

Table 1. Dates of fossil bone samples.

Designation	State and culture period	Date before the present by C <sup>14</sup> analysis or tree-ring count (yr)
UK3	Kentucky, Archaic	4900-5300
UK25	Kentucky, Adena	1170-1510
S76	New Mexico, White Mound	1175
AP692	New York, Frontenac	4370-5385
8450-1	California, Middle	1880

Each bone was first completely hydrolyzed by hydrochloric acid. Then aliquots of the hydrolyzate were analyzed by two-dimensional paper chromatography. This made it possible to identify the presence of traces of amino acids. As a control, we first examined fresh human femurs secured from autopsy and established the presence of the following amino acids: glycine, alanine, serine, valine, leucine, isoleucine, phenylalanine, tyrosine, cysteine acid, proline, hydroxyproline, aspartic acid, glutamic acid, histidine, arginine, lysine and methionine-sulfoxide. This list agrees substantially with that published by Eastoe (5) for fresh bone.

We next investigated a series of 20 fossil human and three fossil animal bones, representing a wide time span from relatively recent to archeologically very old. In bones exposed to burial for comparatively short periods, most of or all the amino acids found in fresh bone are detectable in nearly normal amounts. Some of the samples falling within this classification are shown in Table 1.

In bones the age of which appears to be definitely greater than those shown in the table, the constituent amino acids begin to disappear. We have as yet not developed the quantitative analysis to the point where it is possible to set forth the details of an orderly progression of depletion or retention. Nevertheless, certain amino acids evidently persist in all but the very oldest specimens. Thus, sample 6075 (site FRe-48, California, very ancient) contained only aspartic acid. A human bone, early post-Pleistocene from site LAn-172, California, contained aspartic acid, glycine, and glutamic acid. A mammoth bone from Melbourne, Fla. (site Bre-44, very ancient) and a human bone from site SJo-142 (Early culture period, central California) both contained aspartic acid, glycine, and glutamic acid together with

a few other amino acids which differed between the two samples. Finally, a human bone and a horse bone from Melbourne, Fla. (site Bre-44) both gave tests showing no amino acids whatever.

The preliminary results reported here therefore suggest the conclusion that decomposition of protein in buried bones proceeds extremely slowly over many thousands of years but tends to release in the process certain amino acids while retaining certain others with great tenacity (6).

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18 March 1957

### Behavior of Light- and Dark-Reared Rats on a Visual Cliff

From the 18th century to the present, the empiricist and the nativist theories of depth perception have been vigorously debated. One experiment aimed at resolving the dispute is Lashley and Russell's (1), in which rats reared in darkness jumped to a platform from a stand placed at a variable distance from it. The force of the jump was found to be graded in accordance with the distance of the platform. This is evidence for nativism. But, since the tests with graduated distances were not given until the rats' third day in the light, and after pretraining, the conclusion was not indubitable. Confirmation by another technique is desirable and has been provided in the experiment described in this report (2).

A technique of testing for visual depth perception which involves no pretraining at all—the "visual cliff"—was developed. It is based on the assumption that, given a choice, an animal will avoid descending over a vertical edge to a surface which appears to be far away (3). The apparatus (Fig. 1) was constructed of two thicknesses of glass (24 in. by 32 in.), parallel to the floor and held by metal supports 53 in. above it. A board (4 in. wide, 24 in. long, and 3 in. high) extended across the glass, dividing it into two equal fields. On one side (the "near" side), patterned wallpaper was inserted between the two sheets of glass. Through



the clear glass of the other side (the "far" side) the same pattern was visible on the floor and also on the walls below the glass surface.

Optically speaking, the edge on one side of the board dropped away for a distance of 53 in. (making the simulated cliff), while on the other side the edge dropped away for only 3 in. Thus, two visual fields existed, both filled with patterned wallpaper, but the pattern of the "far" field was optically much smaller and denser than that of the other and elicited more motion parallax. (More binocular parallax was also possible at one edge than at the other, but the rat is probably insensitive to this cue.) The fields were matched for reflected luminous intensity. The physical space, as distinguished from the optical space, was identical on both sides, since a glass surface was present at a distance of 3 in. The only difference between the two fields, therefore, was a difference in optical stimulation. Other possible cues for safe descent (tactual, olfactory, auditory echolocation, air currents, or temperature differentials) were equalized by the glass.

In addition to the experimental condition described here, a control condition was included, in order to check on the presence of any unknown factors that would make for a preference for one side. A piece of wallpaper was inserted between the glass on both sides (Fig. 2); otherwise, the apparatus was identical to that for the experimental condition. If controls are adequate, animals should show no preference for either side in this case.

Subjects for the experimental condition were 19 dark-reared, hooded rats, 90 days old, and 29 light-reared litter mates. Twenty minutes after coming into the light, the dark-reared rats were placed on the apparatus. An animal was

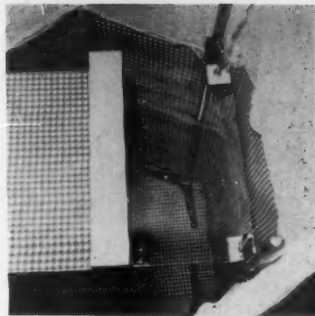
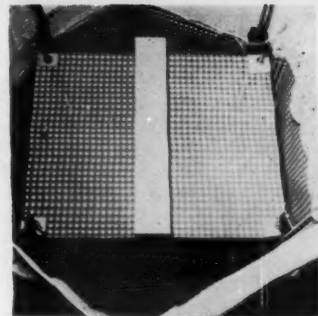


Fig. 1 (left). Apparatus for the experimental condition. The larger-checked field is the "near" side, optically; the clear glass field is the "far" or "cliff" side. Fig. 2 (right). Apparatus for the control condition.



placed on the center board in a box, to avoid any handling bias. It was then observed for 5 minutes. Results are summarized in Table 1. The percentage of animals that descended on the near side was not significantly different for light- and dark-reared rats. Of the light-reared rats, 23 descended on the near side, three descended on the far side, and three remained on the board for all 5 minutes. Of the dark-reared rats, 14 descended on the near side, three descended on the far side, and two remained on the board.

But a comparison of descent behavior of the experimental animals with the controls, for whom the visual surface was near on both sides, showed a difference. The control group, all light-reared litter mates of the experimental group, showed no preference in descending from the board; five went to each side. This group differs significantly from the experimental group ( $p < 0.02$ ).

Even more interesting is a comparison of the exploratory behavior of the animals. The light-reared and dark-reared rats of the experimental group again behaved similarly; most of them stayed on

the side of the center board that they had first chosen. Of the 43 experimental animals that descended from the board, only one crossed to the other side. But the control animals explored back and forth, often crossing the board to the other side several times. The difference in crossing behavior between experimental and control groups is highly significant ( $p < 0.001$ ). The percentage of time spent on the two sides confirms the other measurements. Both experimental groups spent more than twice as much time on the side with the near optical pattern as on the side with the far optical pattern, while the control animals reversed this trend.

These results suggest two conclusions. First, hooded rats, 90 days of age, do discriminate visual depth or distance. They avoid a visual cliff as compared with a short visual drop-off, and this preference is eliminated when the visual cliff is eliminated. Second, such discrimination seems to be independent of previous visual experience, since dark-reared adult animals behaved like their light-reared litter mates only 20 minutes after being exposed to the light.

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2. This research was supported, in part, by a grant from the National Science Foundation. We wish to thank J. J. Gibson, for suggestions about apparatus and stimulus conditions.
3. The work of K. T. Waugh [*J. Comp. Neurol.* 20, 549 (1910)] and J. T. Russell [*J. Genet. Psychol.* 40, 136 (1932)] makes this assumption seem plausible. Latency of jumping or "discrimination to jump" apparently increased as distance increased.

1 May 1957

Table 1. Comparison of light- and dark-reared animals on a visual cliff (experimental group) and comparison of both with a no-cliff control group.

	Experimental group		Control group
	Light-reared ( $N = 29$ )	Dark-reared ( $N = 19$ )	Light-reared ( $N = 10$ )
Percentage descending on "near" side	88.5	82.4	30.0
Mean No. crossings	0.00	0.06	1.70
Percentage of time			
On "near"	76.0	57.9	24.1
On "far"*	10.0	16.9	61.5
On board	14.0	25.2	14.4

\* The control group had no optically "far" side. Reference is to the same physical side that was "far" for the experimental group.

## Book Reviews

**The Presentation of Technical Information.** Reginald O. Kapp. Macmillan, New York, 1957 (published in Great Britain, 1948). 147 pp. \$1.95.

Among the peculiarities of modern man to which psychologists have given all too little attention are the pride of the intellectual in avoiding physical exercise, the pride of the man in the street in avoiding mathematics, and the pride of the expert in avoiding plain talk. The last of these three interesting phenomena is the concern of this little book on writing. The author is an Englishman, reminding us that murder of the King's English is as common in England as in the United States. His book is based on a course in exposition given for post-graduate students of engineering at University College, London. What makes it outstanding among such courses and books is that it not only has many helpful things to say about the mechanics of writing but also goes to the heart of the scientist's and engineer's problem of communication.

Reginald Kapp starts from the unarguable fact that communication of scientific work nowadays is virtually as important as the work itself. The scientist's day "is crowded with talks, conferences, committees." He must report what he is doing to his colleagues, to team mates from other sciences, to his sponsors, often to industry or the public at large. Unfortunately, there is no royal road to communication, any more than to the solution of a scientific problem. Successful communication is hard work. All too often the writers of scientific papers leave all the work to the reader—"to put into the right order in his mind what is in the wrong order in the paper, to draw the conclusions he is meant to even when they are not stated, to jump without any guidance to the significance of a statement, to bridge any gap the author's carelessness may have left in a line of reasoning."

Of course, no reader is going to do all this work except under extreme necessity. "He gives his attention only to those who know how to earn it and hold it. So those scientists and philosophers who neglect the problems of presentation should ponder on the fate of all tyrants

in history. If they argue that these problems are too insignificant for their exalted study, if they plead that their time is valuable, they should reflect that the time of the person addressed is valuable too. If he can help it, this person will not waste his time quarrying [to dig out the ore]. In the end, the proud scientist or philosopher who cannot be bothered to make his thought accessible has no choice but to retire to the heights in which dwell the Great Misunderstood and the Great Ignored, there to rail in Olympic superiority at the folly of mankind."

What Kapp has to say applies to the communication between one scientist and another as well as between scientists and the larger public. Basically, the defects of most scientific writing in our day are logical and psychological: failure of the author (i) to present his thought lucidly and (ii) to consider the person he is addressing. This is not to overlook the fact that important contributions to the unreadability of much scientific writing are made by unnecessary impediments of pretentious language, clumsy sentence structure, and so forth. But good writing is more than a matter of simple language and accurate grammar, important as these are. It calls for clear, logical, and orderly development of the author's thesis. The account should be related to the reader's knowledge and understanding and must provide him with a map which "helps him to know from moment to moment where he is, how he got there, and in which direction his path lies." Kapp's book sets forth some specific and sensible precepts on how to achieve that kind of writing.

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**Handbuch der Laplace-Transformation.** vol. III, *Anwendungen der Laplace-Transformation*. Gustav Doetsch. Birkhäuser, Basel, 1956. 300 pp. Illus.

*Anwendungen der Laplace-Transformation*, by one of the outstanding European mathematicians, is the third of a trilogy comprising an inclusive account of the theory and application of the La-

place transform. The first volume, *Theorie der Laplace-Transformation* (1950), encompasses an inclusive treatment of the "pure" mathematical theory of the Laplace transform. The second volume, *Anwendungen der Laplace-Transformation* (1955) and the present third volume comprise, *in toto*, a unified account of that further body of theory which is particularly pertinent to solution of problems in engineering, physics, and applied mathematics and illustration of its use by numerous examples in these domains.

Volume II includes asymptotic representations, convergent representations, and solution of ordinary differential equations by Laplace transform techniques; each of these major topics forms one of the three major parts of the book. The present volume III encompasses a detailed treatment of the solution of partial differential equations, difference equations, and integral equations by Laplace transform means and a complementary account of entire functions of exponential type and of finite Laplace transforms. Each phase constitutes one of the four major divisions of the text. Unification of the two volumes into a single connected work is accomplished by continuing, from volume II through volume III, the numbering of the major subdivisions of the text (volume II: parts I-III; volume III: parts IV-VII) and of the chapter headings (volume II: chapters 1-16; volume III: chapters 17-32). Obviously, therefore, anyone who has volume II will want to obtain the complementary volume III.

This is divided into four major sections. The essential content, range of treatment, grouping of material, and relative stress on different topics is well epitomized in the following summary which includes free translation of the 16 chapter headings, pertinent inclusive page numbers, and brief accounts of the principal purpose that underlies the treatment of each section.

Part IV, "Partial differential equations," embraces five chapters: "Generalities concerning partial differential equations and their integration by means of Laplace-transforms" (pages 13-21); "Partial differential equations of the second order with constant coefficients" (pages 22-61); "Partial differential equations with variable coefficients" (pages 62-69); "Uniqueness theorems and compatibility conditions for boundary and initial conditions" (pages 70-78); and "Huygen's and Euler's principles" (pages 79-88).

These chapters comprise an excellent account of the single Laplace transform solution of partial differential equations in two variables with constant and, more briefly, certain types of variable coefficients under prescribed conjoined initial and boundary conditions. They

detail the particular pitfalls and delicacies that attend legitimate encompassment of certain kinds of prescribed conditions, and conclude with a concise account of the connection between solution of a problem by Laplace transforms and by functional analysis through the common denominator of the role of the pertinent Green's function. Illustration of application of this theory is drawn largely from well-known problems in the two domains of heat flow in thermally conducting planar areas and of voltage and current propagation in electric transmission lines.

Part V, "Difference equations," includes three short chapters: "Ordinary difference equations in the original domain" (pages 91-106); "Ordinary difference equations in the transform domain" (pages 107-115); and "Partial difference equations" (pages 116-130). This division of content advances the basic theory that underlies transform solution of ordinary difference and difference-differential equations in one ordinary variable (for example,  $t$ ) and application to determination of current response in resistive ladder networks; the solution of ordinary and difference-differential equations in the Laplace variables, with exemplification through the classic functional equation of the gamma function; and solution of partial differential and difference-differential equations in the original domain, with the subtler details underscored through solution of two problems in planar heat conduction.

Part VI, "Integral equations and integral relationships," comprises six substantial chapters: "Integral equations of real convolution type in the finite interval" (pages 133-171); "Integral equations of real convolution type in the infinite interval" (pages 172-186); "Functional relations among real convolution integrals, especially transcendental addition theorems" (pages 187-198); "Integral equations of complex convolution type" (pages 199-208); "Correspondences between complex convolution integrals of transform functions and products of their original inverse functions" (pages 209-214); and "Various types of integral equations solvable by use of Laplace transforms" (pages 215-221).

These chapters comprise a thorough exploration of the basic theory pertinent to solution of the Volterra-type equation in which the kernel depends only on  $(t-\tau)$ ; thus, with kernel,  $K(t-\tau)$ . In such an equation the encompassed integral comprises a convolution transform, and this fact affords a very desirable conciseness and unification of theory of solution through the use of earlier developed Laplace transform theory. Thus, solution of linear integral equations of the first and second kind, to which one-

sided and two-sided Laplace transforms are respectively pertinent, is detailed and illustrated by consideration of such familiar examples as Abel's integral equation. Next, inversion of products of transforms with parameters that satisfy the algebraic addition theorem is shown to be easily accomplished by use of the pertinent transcendental addition theorem. This is supported by numerous examples that involve the theta, Bessel, and hypergeometric functions, the Hermite and Laguerre polynomials, and other entities of the transcendental realm of functional analysis. Next, a somewhat analogous body of work is advanced for integral equations in which the independent variable is the transform variable  $s$ . The concluding chapter of this section illustrates, through specific examples, other equations, of various types, whose solution is facilitated by Laplace transform techniques; these include equations that can be transformed into equations of known solution, with kernels whose Laplace transforms are exponential functions, with kernels that are involutorial in nature, and so forth.

The final part VII, "Entire functions of exponential type and finite Laplace transforms," includes two short chapters: "The finite Laplace-transform" (pages 225-232) and "Entire functions of exponential type" (pages 233-254). Essentially, these give, in detail, basic theory of existence, inversion, and so on of finite transforms of both classes I and II and illustration of use to obtain the mean-squared-value of functions of exponential type and to investigate certain relationships on its derivatives.

The main text is supported by a "Foreword"; short "Connective remarks"; a "Table of contents"; "Addenda to volume I" (pages 253-259); a lengthy "Literature and historical commentary" (pages 261-276) that gives illuminating critical comment and historical data pertinent to various points in the text; a list of "Books" that are especially concerned with applications of Laplace transforms (it may be of value to note, for the benefit of the interested reader, that during the past decade I have been able to purchase all of the 24 items that are listed, with the exception of those by Droste and Schulz, stocks of which were evidently destroyed in Berlin during World War II); a lengthy "Bibliography" (pages 279-286) of periodical articles and books, arranged alphabetically by author; a "Subject index"; a list of "Amendments to Volume II"; and a listing of the major division headings of volumes I and II.

In physical aspect this volume is of the same excellence as are the earlier volumes. It has glossy paper of high quality, stout board covers in an attractive green cloth binding, superlative typography,

nicely displayed equations, detailed line drawings, and a convenient page size. The textual content is couched in a lucid style that materially aids the reader to grasp the theoretical developments and supporting illustrative examples. The accuracy of theory, precision of statement, and detail of treatment are evidence of the breadth of knowledge, originality, and command of application that stamp the author as one of the foremost European mathematicians in the domain of Laplace transform analysis.

This volume, like its predecessors, will of course prove to be of greatest interest to mathematicians, particularly to those concerned with analysis and applied mathematics. However, because of the power, utility, and rapidly increasing use of integral transforms—especially of Laplace transforms—for the solution of specified problems or the development of general theory in all branches of present-day physics, chemistry, and celestial mechanics and in every domain of engineering and associated technologies (especially in such difficult phases as variable-media wave-propagation theory and nonlinear system analysis, where integral equation formulations provide especially fruitful means of solution), this volume deserves close study and assimilation by all physical scientists and engineers who wish to keep abreast of those developments in mathematical analysis which underlie the analytic foundations of their own domains of professional endeavor.

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**Laboratory Engineering**, vol. III, pt. II of *Technique of Organic Chemistry*. Arnold Weissberger, Ed. Interscience, New York, ed. 2, 1957. 391 pp. Illus. \$8.

The first edition of *Laboratory Engineering* treated the general engineering aspects of operations used in preparative organic chemistry. In the new second edition, the volume has been split into two parts. The first part deals with separational methods, while part II is concerned with the engineering type of problems commonly encountered in the chemical laboratory.

The book is divided into five sections. Two of the sections on "Mixing" and "Heating and cooling" have been updated from the first edition, while the other three sections, "Operations with gases," "Selection of materials for the construction of equipment," and "Grinding, screening, and classifying," are completely new. All of the sections emphasize applications of equipment and engineering methods in the laboratory or in small-scale plants. The purpose of the



book is to supply the chemist with information that he can use directly in his laboratory. As a result, the treatment is mainly from a practical viewpoint, with little emphasis on theory or basic principles.

Approximately one-half of the section on materials of construction is devoted to the corrosion of metals, while the remaining part gives a brief treatment of physical properties for metals and non-metals. A number of different methods for measuring pressures and gas flow rates are discussed in the section on operations with gases. This section also presents an excellent, although brief, treatment of valves for use on gas lines.

Although the sections on heating and cooling, mixing, and grinding, screening, and classifying do include a small amount of elementary theory, they are devoted primarily to a discussion of equipment for carrying out these operations. The chemist who has no engineering background will find that these sections clearly explain the use of the various types of laboratory engineering equipment.

The book is well written, and, in general, the material requires little technical background for a complete understanding. The approach is almost completely qualitative, and most of the book is devoted to description of equipment. The engineer will find that very little information is presented that is not already well covered in the various textbooks and handbooks on chemical engineering. However, the chemist, and in particular the organic chemist, will find that the book fulfills its purpose of supplying a useful, concise, and fairly complete coverage of engineering methods and equipment for laboratory applications.

M. S. PETERS

University of Illinois

**The Leibniz-Clarke Correspondence.** Together with extracts from Newton's *Principia* and *Opticks*, edited with introduction and notes by H. G. Alexander. Philosophical Library, New York, 1956. 200 pp. \$4.75.

In the years 1715-16 Leibniz, the greatest philosopher on the Continent, engaged in a critical correspondence with Samuel Clarke, a scientific-minded theologian, a friend and disciple of Isaac Newton. It was through the efforts of Caroline, Princess of Wales, to whom Leibniz had first written a criticism of the theological implications of Newtonian philosophy, that this exchange of letters took place. Clarke had Newton's help in composing his replies and attacks. Thus, in effect, these letters reveal the coming to grips of the thought of the

two greatest philosophic and scientific minds of that great age.

Behind this correspondence lay the long-standing controversy between Leibniz and Newton concerning the invention of the calculus. Fundamental differences in outlook, both scientific and philosophic, were factors in this quarrel. But these were obscured as the course of the debate took an increasingly bitter and shameful turn. The Leibniz-Clarke exchange is a far more temperate and significant reexamination of these differences.

Although the correspondence begins with certain theological considerations, the argument soon goes on to cover the range of basic philosophic-scientific ideas—the central topics of that branch of learning then known as “natural philosophy.” So we find Leibniz criticizing the Newtonian account of gravity and the existence of a vacuum. He advances his own theory of space and time, in which these are taken to be relational and mathematically “ideal” orders, as against Newton's treatment of them as absolute and, in some sense, independently existing “substances.” It remained for later readers to point out the critical difficulties to be found in both positions. But the letters draw the differences sharply and clarify the problems. Hence, they were to serve as valuable guides to all subsequent understanding of the thought of Leibniz and Newton and to provide a fertile source for future work on the problems they raise.

It is surprising, in view of the interest and historical significance of the correspondence, that the present book is the first complete English edition to be published since 1738. The original text is here, in modernized spelling and type. In appendixes the editor has wisely included pertinent selections from Newton's *Principia* and *Opticks* and from letters by Leibniz (and one by Newton) all bearing on issues that relate to the correspondence. These valuable additions to the original work are supplemented by H. G. Alexander's informative footnotes in the text. Furthermore, he has written a clear and thoughtful 50-page introduction, which surveys and discusses the problems raised in the letters and briefly traces some of the major phases of the subsequent history of the space-time controversy, from Berkeley and Euler, through Kant, to Mach and Einstein.

A few of the things Alexander has to say in this generally able discussion will cause some disagreement. The critical comments on Leibniz, for example, are not altogether clear. This may be partly due to the fact that not only is Leibniz difficult but we do not as yet have full access to his thought and to those of his writings that are still preserved for us.

[There exists no complete edition of Leibniz. The first ample edition of his papers to appear in English has just been published by the University of Chicago Press (1957)]. It is not an easy matter to disengage “metaphysical” from “scientific” ideas and interests in Leibniz. It is very easy to be misled by his language into viewing the controversy as theology-metaphysics (Leibniz) versus mathematical science (Newton). Actually, all of these interests are shared by both sides to the controversy.

These are, however, relatively minor considerations and Alexander is to be congratulated for making this classic available and presenting it to us in a competent and attractive form. No secondary account can reproduce the vitality and contagious interest with which the Leibniz-Clarke debate was conducted. This book will prove valuable reading for all those with an interest in the background of modern science and philosophy.

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**Hormones, Brain Function, and Behavior.** Proceedings of a conference on neuroendocrinology held at Arden House, Harriman, N.Y., 1956. Hudson Hoagland, Ed. Academic Press, New York, 1957. 257 pp. Illus. \$7.

Neuroendocrinologists have provided us with numerous clues to endocrine physiology since the studies and treatise of William Buchan of Edinburgh, who in 1779 stated that “the passions have great influence both in cause and cure of diseases. How mind acts upon matter will, in all probability, ever remain a secret. It is sufficient for us to know that there is established a reciprocal influence betwixt the mental and corporeal parts, and that whatever disorders the one, likewise affects the other.” In this regard, Buchan's treatise remained as a challenge to future investigators, and the progress made in neuroendocrinology gives witness to the wide acceptance of the carefully documented challenge.

*Hormones, Brain Function, and Behavior* highlights the thinking of certain investigators concerned with (i) steroids in neuropsychiatry (R. A. Cleghorn); (ii) effects of adrenocortical steroids on the brain (D. M. Woodbury, P. S. Timiras, and A. Vernadakis); (iii) steroid anesthetic and brain metabolism (H. W. Elliott, B. F. Krueckel, and V. C. Sutherland); (iv) determinants of sexual behavior patterns (W. C. Young); (v) control of sex behavior in animals (Allan C. Goldstein); (vi) serotonin in mental disorders (D. W. Woolley); (vii) biochemical studies on, and physiological



implications of, serotonin (S. Udenfriend, H. Weissbach, and D. F. Bogdanski); (viii) central neurohumoral agents (B. B. Brodie and P. A. Shore); (ix) adrenolutin as a psychotomimetic agent (A. Hoffer); (x) metabolism of thyroid hormones by brain tissue (J. R. Tata); (xi) thyroid treatment and appetite for alcohol (C. P. Richter); and (xii) thyroid hormones and mental health (R. W. Rawson, H. Koch, and F. F. Flach).

The section on serotonin is especially good. Woolley concludes: "... sufficient evidence has been found to suggest that serotonin plays a role in the brain, and that the pharmacological interference with this function there may influence mental and neurological processes. There is no proof that these relatives (analogs) of serotonin do not affect other processes aside from those concerned with serotonin, and these other processes may be of great importance. However, the use of analogs of serotonin has brought to light so many phenomena related to mental function as to suggest a participation of this hormone in normal mental process." Furthermore, the biochemical studies on serotonin by Udenfriend, Weissbach, and Bogdanski provide additional evidence indicating that serotonin has a role in the function of the brain: (i) serotonin is found in the brain, (ii) enzymes which both make and destroy serotonin are found there, and (iii) increasing amounts of serotonin in the brain, as with 5-hydroxytryptophan, or decreasing it by pyridoxine deficiency produce marked central difficulties. Finally, the pharmacological effects produced by indole drugs give added proof of an important central function for serotonin.

Allan C. Goldstein's chapter, which includes a large amount of work accomplished in association with Frank A. Beach, is a rather thorough account of numerous observations on the experimental control of sex behavior in animals. From these observations it is rather evident that the lower spinal cord, the hypothalamus, the amygdaloid complex, and the cerebral cortex are important structures for the sexual act. As for the status of our knowledge pertaining to a relationship between hormone action and neural functioning, Goldstein admits that little is known beyond what was said by Beach and Philip Bard in 1940. The development of newer techniques, however, provides promise of obtaining pertinent information in this area.

The title of this book is somewhat out of proportion to the subject matter it contains. Notably absent are the groundbreaking contributions of G. W. Harris, J. D. Green, C. H. Sayer, A. Rathballer, Jacob de Groot, G. Sayers, David Hume, and Monte Greer. These names are synonymous with neuroendocrinology. The

value of this little book could have been greatly enhanced by the incorporation of the newer observations from Harris and his school and from the Los Angeles group.

JOSEPH T. VELARDO  
Yale University School of Medicine

#### Models of Man. Social and rational.

Mathematical essays on rational human behavior in a social setting. Herbert A. Simon. Wiley, New York; Chapman & Hall, London, 1957. 287 pp. \$5.

Herbert Simon's 16 "mathematical essays on rational human behavior in a social setting," gathered together under the title *Models of Man*, have appeared in recent years as separate technical articles. He has organized them into four groups and prefaced each section by a short introduction that establishes the common theme. Although the mathematical demands are not unduly severe or the mathematics unconventional, the book will be accessible mainly to those who have some knowledge of the general problem area and some technical facility with classical mathematics. Social scientists who possess the requisite skills should find much of the volume congenial. It is not polemic. ("In the long run, mathematics will be used in the social sciences to the extent that it provides a sufficiently powerful language of analysis and exposition to justify the time and effort required to use it.") And, in several of the papers, Simon has taken a well-known social theory as his starting point (see, for example, his formalizations of Festinger's and Homans' theories of group interaction).

There are three central, but independent, themes in the book: causation, social adaptation, and limited rationality. In the first series of essays, causation is treated essentially as unilateral interaction within a dynamic system, which is what Simon feels that practicing scientists—in contrast to philosophers—mean by the concept. The analysis is limited to those dynamic systems that can be described by certain fairly narrow classes of equations. These ideas for handling asymmetric relations are then applied to two substantive problems: political power and the influence of a social prediction (for example, prediction of the outcome of an election) on the actual outcome.

The first three papers on social adaptation, which formalize three current theories of group process, use familiar differential equation techniques to study social equilibria and stability in human groups that are characterized in terms of certain aggregated group vari-

ables. As in the theories, no real analysis of the nature of the basic variables is presented, and, although this question is discussed in the introduction to the section, it is not disposed of to my satisfaction. "Friendliness," "activity," and "pressure to communicate" are extremely subtle, complex notions that are not clearly numerical in nature, and any model that assumes that they are may well have a fragile foundation. The final essay in this section—the best of the 16, to my mind—offers a general statistical mechanism to account for the diverse social distributions that exhibit the relationship known as Zipf's "law" or the rank-size rule.

Simon's final thesis is that "it is time to take account—and not merely as a residual category—of the empirical limits on human rationality, of its finiteness in comparison with the complexities of the world with which it must cope." He advocates a principle of bounded rationality under which, among other things, the goal of maximizing is to be replaced by what he calls "satisficing"—that is, achieving a criterion. What he means is amply illustrated in a variety of special cases, but nowhere is it formulated in sufficient generality to be really competitive with the traditional optimizing ideas.

The book suffers from what I am afraid must be the fate of any collection of journal articles. They have been written for experts and, hence, take for granted a familiarity with the literature, on the part of the reader, that cannot be supplied by the short connective sections. At the same time, in articles that were originally directed to different audiences, there is bound to be some redundancy and unevenness of level. Since Simon has a flair for exposition, we can only regret that he did not elect to rework this material into a fully integrated book.

R. DUNCAN LUCE  
New York, New York

#### New Books

*General and Applied Entomology*. V. A. Little. Harper, New York, 1957. 551 pp. \$7.

*The Terpenes, vol. IV, The Triterpenes and Their Derivatives: Hydrocarbons, Alcohols, Hydroxy-aldehydes, Ketones and Hydroxy-ketones*. The late Sir John Simonsen and W. C. J. Ross. Cambridge University Press, New York, 1957. 533 pp. \$13.50.

*Psychology, Evolution and Sex*. Cecil P. Martin. Thomas, Springfield, Ill., 1957. 179 pp.

*The Journal of a Scientist*. Piero Modigliani. Philosophical Library, New York, 1957. 136 pp. \$3.75.

*Radioactivity and Nuclear Physics*. James M. Cork. Van Nostrand, Princeton, N.J., ed. 3, 1957. 427 pp. \$7.75.

# Meetings and Societies

## Junior Academies of Science

A Conference on Junior Academies of Science was held in Chicago, 15-16 Feb. This conference was jointly sponsored by the Academy Conference of the American Association for the Advancement of Science and the Museum Division of the Oak Ridge Institute of Nuclear Studies and was supported by a grant from the National Science Foundation. The undergraduate Division of the University of Illinois, Navy Pier Campus, acted as host.

Seventy-seven persons registered. The first general session was presided over by Dewey Large. It consisted of an address of welcome by Charles C. Caveny, responded to by P. H. Yancey; "Backgrounds and objectives of the conference with respect to junior academies in the American Association for the Advancement of Science" by Thelma C. Heatwole; and a briefing of concurrent sessions by Yancey.

The first general session was followed by a luncheon presided over by Harold W. Bailey. Charles G. Wilder of ORINS introduced the speaker, E. T. McSwain, School of Education, Northwestern University, who spoke on "Opportunities in secondary education."

The second general session was presided over by Yancey. Reports from the concurrent sessions were read and discussed, and the following proposals were made to the Academy Conference.

1) That the encouragement of young people in scientific investigation be the major interest of junior academies of science. This may be accomplished through the presentation of their work in science meetings, exhibits, or fairs, and such other activities as are consonant with the aims of junior academies.

2) That the Academy Conference of the AAAS be requested to establish a national clearinghouse of information for junior and senior academies, with adequate editorial and secretarial staff and necessary services, including publications and/or the use of appropriate existing publications. Furthermore, the Academy Conference is urged to explore ways and means of implementing the employment of a full-time junior academy field worker in each state.

3) That there be an annual meeting of representatives of junior academies. This would be held in conjunction with

the Academy Conference at the AAAS convention.

4) That senior academies give greater recognition to deserving science teachers, and that, where possible and feasible, distinguished service awards be made to outstanding science teachers.

5) That the Academy Conference give suitable and appropriate awards to selected junior academies of science for outstanding performance and achievement.

6) That each junior academy of science be encouraged to develop a constitution and bylaws acceptable to the senior academy.

7) That junior academies should basically represent organizations of science clubs under the sponsorship of senior academies. Further, that the junior academy program should be a year-round activity, with science exhibits forming an integral part of the program.

8) That junior academy regional work conferences be held and that representatives of states not currently represented by junior academies also be invited to attend these conferences to obtain information on junior academies.

9) That a junior academy handbook be prepared and made available to science teachers. Such a handbook should include ideas for projects and for organizing and administering junior academy programs.

10) That the National Science Teachers Association, the National Association of Biology Teachers, and the American Chemical Society be urged to include in their convention programs a session concerned with the activities of junior academies of science.

THELMA C. HEATWOLE  
1411 Churchville Street,  
Staunton, Virginia

## Oak Ridge Symposium

A symposium on high-energy physics will be held in Oak Ridge, Tenn., 19-24 Aug., under the joint sponsorship of Oak Ridge National Laboratory and the Oak Ridge Institute of Nuclear Studies. The 6-day program will be conducted on an introductory level and will be addressed to scientists who have not previously been working in the field of high-energy, or elementary-particle, physics.

The lectures and conference leaders scheduled to take part in the symposium are Maurice Neuman and L. Alvarez, University of California; Martin Block, Duke University; G. T. Zorn, Brookhaven National Laboratory; A. Pevsner, Johns Hopkins University; Val L. Fitch, Princeton University; and Professor D. T. King, University of Tennessee. Subjects on the program include the theory of elementary particles and their interactions, experiments using the nuclear-emulsion techniques, experiments using bubble chambers, and counter experiments.

In addition to the formal lectures, there will be informal discussions on all aspects of high-energy physics, and the participants will have the opportunity to obtain experience with emulsion-track and bubble-chamber picture-track measurements during the course of the symposium. Further information about the symposium may be obtained by writing the University Relations Division, Oak Ridge Institute of Nuclear Studies, Box 117, Oak Ridge, Tenn.

## Liquid Scintillation Counting

The National Science Foundation has made an award of \$4000 to Northwestern University to support in part the Northwestern University Conference on Liquid Scintillation Counting to be held on 20-22 Aug. at the Technological Institute, Evanston, Ill. The grant will be used to bring five specialists to the conference from England, France, Germany, and the Sarre.

The conference, which has no commercial sponsors, will be the first devoted exclusively to liquid scintillation counting and will cover most phases of the field in theory and applications: coincidence counters, single-channel counters, chemistry of liquid scintillators, and applications in biology and medicine, industry, archeology, physics, chemistry and engineering. Persons interested in giving short papers at the conference are invited to submit abstracts to Dr. F. N. Hayes, Los Alamos, N.M. Other information can be supplied by C. G. Bell, Northwestern University, Evanston, Ill.

## For:coming Events

### August

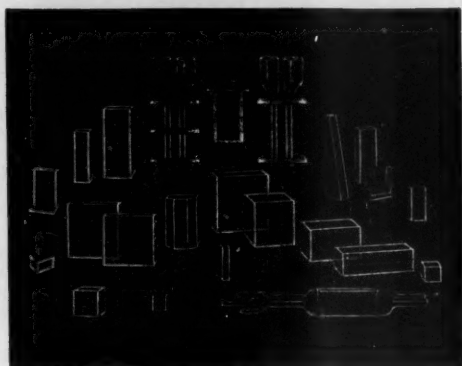
12-16. Canadian Teachers' Federation, annual, Edmonton, Alberta, Canada. (G. G. Croskery, 444 MacLaren St., Ottawa 4, Ont.)

12-18. Theory of Functions, international colloquium, Helsinki, Finland. (B. Eckmann, Ecole Polytechnique, Federale, Zurich, Switzerland.)

12-25. International Soc. of Soil Mechanics and Foundation Engineering 4th Conf., London, England. (A. Banister,

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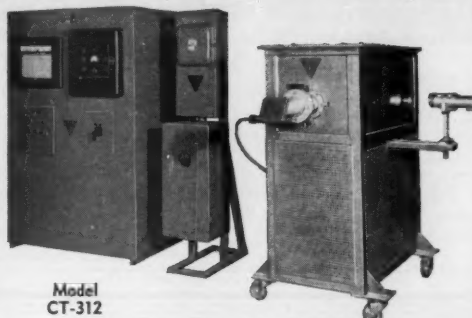
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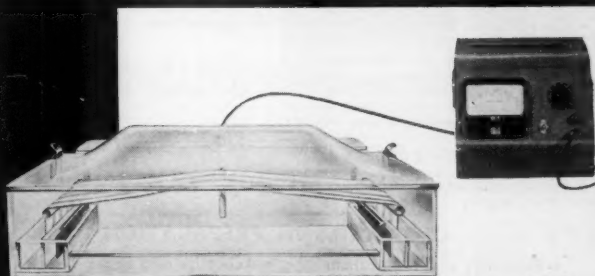
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18-21. American Astronomical Soc., Urbana, Ill. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

19-21. National Council of Teachers of Mathematics, Northfield, Minn. (M. H. Ahrendt, NCTM, 1201 16 St., NW, Washington 6.)

19-22. American Veterinary Medical Assoc., annual, Cleveland, Ohio. (J. G. Hardenbergh, AVMA, 600 S. Michigan Ave., Chicago 5, Ill.)

19-23. Clay Conf., 6th natl., Berkeley, Calif. (Dept. of Conferences and Special Activities, Univ. of California Extension, Berkeley 4.)

19-23. Clinical Chemistry, 2nd international European cong., Stockholm, Sweden. (K. Agner, Box 12024, Stockholm 12.)

19-23. Plant Science Seminar, 34th annual, Montreal, Quebec, Canada. (F. L. Mercer, St. Louis College of Pharmacy, St. Louis 10, Mo.)

19-24. Finite Groups, internatl. colloquium, Tübingen, Germany. (H. Wielandt, Faculty of Mathematics and Natural Science, Eberhard-Karls-Universität, Tübingen.)

19-24. High Energy Physics Symp., Oak Ridge, Tenn. (University Relations Div., Oak Ridge Inst. of Nuclear Studies, P.O. Box 117, Oak Ridge.)

19-24. New England Assoc. of Chem-

istry Teachers, 19th summer conf., Waterville, Maine. (Rev. J. A. Martus, College of the Holy Cross, Worcester 10, Mass.)

19-24. Origin of Life, internatl. symp., Moscow, U.S.S.R. (G. A. Deborin, Inst. of Biochemistry, U.S.S.R. Acad. of Sciences, B. Kaluzskaya 33, Moscow, B.71.)

20-22. Liquid Scintillation Counting Conf., Evanston, Ill. (C. G. Bell, Jr., Technological Inst., Northwestern Univ., Evanston.)

20-23. Western Electronic Convention, annual, San Francisco, Calif. (D. B. Harris, Electron Tube Research, General Electric Microwave Lab., Palo Alto, Calif.)

21-24. Pi Lambda Theta, New York, N.Y. (C. Johnson, Pi Lambda Theta, 307 Portland Bldg., 1129 Vermont Ave., NW, Washington 5.)

22-5. International Scientific Radio Union, 12th general assembly, Boulder, Colo. (K. A. Norton, Boulder Laboratories, National Bur. of Standards, Boulder.)

24-26. International Soc. for Biological Rhythm, 6th conf., Semmering, Austria. (A. Sollberger, Anatomical Department, Karolinska Institutet, Stockholm 60, Sweden.)

25-27. Pacific Division-AAAS, annual, in conjunction with American Inst. of Biological Sciences, Stanford, Calif. (R. C. Miller, California Academy of Sciences, Golden Gate Park, San Francisco, Calif.)

25-28. American Farm Economic Assoc., natl., Asheville, N.C. (L. S. Hardin, Dept. of Agricultural Economics, Purdue Univ., Lafayette, Ind.)

25-29. American Institute of Biological Sciences, annual, Stanford, Calif. (H. T. Cox, AIBS, 2000 P St., NW, Washington 6.)

The following 28 meetings are being held in conjunction with the AIBS meeting at Stanford, Calif.

American Bryological Soc., annual. (W. C. Steere, Dept. of Biological Sciences, Stanford Univ.)

American Fern Soc., annual. (I. L. Wiggins, Dept. of Biological Sciences, Stanford Univ.)

American Microscopical Soc., annual. (G. M. Smith, Dept. of Biological Sciences, Stanford Univ.)

American Phytopathological Soc., annual (W. B. Hewitt, Dept. of Plant Pathology, Univ. of California, Davis). 26-28 Aug. only.

American Soc. for Horticultural Science, annual. (H. P. Olmo, Dept. of Viticulture, Univ. of California, Davis.)

American Soc. of Human Genetics. (E. J. Gardner, Dept. of Zoology, Utah State College, Logan.)

American Soc. of Ichthyologists and Herpetologists. (W. C. Brown, Menlo College, Menlo Park, Calif.)

American Soc. of Limnology and Oceanography. (D. E. Wohlschlag, Dept. of Biological Sciences, Stanford, Univ.)

American Soc. of Naturalists, annual. (D. Perkins, Dept. of Biological Sciences, Stanford Univ.)

American Soc. of Plant Physiologists, annual. (W. R. Briggs, Dept. of Biological Sciences, Stanford Univ.)

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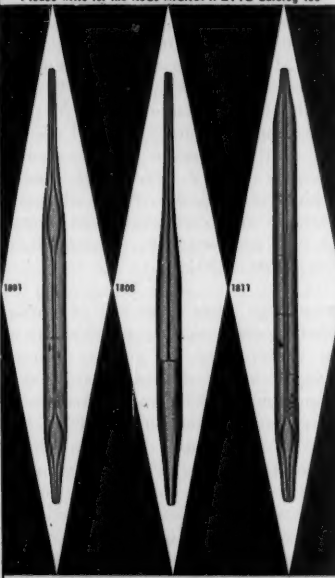
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American Soc. of Plant Taxonomists, annual. (I. L. Wiggins, Dept. of Biological Sciences, Stanford Univ.)

American Soc. of Zoologists, annual. (J. F. Oliphant, Dept. of Biological Sciences, Stanford Univ.)

Biometric Soc., WNAR. (D. E. Wohl-schlag, Dept. of Biological Sciences, Stanford Univ.)

Botanical Soc. of America, annual. (W. C. Steere, Dept. of Biological Sciences, Stanford Univ.)

Ecological Soc. of America, annual. (I. L. Wiggins, Dept. of Biological Sciences, Stanford Univ.)

Genetics Soc. of America, annual. (D. Perkins, Dept. of Biological Sciences, Stanford Univ.)

Mycological Soc. of America, annual. (R. M. Page, Dept. of Biological Sciences, Stanford Univ.)

National Assoc. of Biology Teachers. (Miss E. Larson, Box 2841, Carmel, Calif.)

Nature Conservancy, annual. (W. Drake, Canyon, Calif.)

Phycological Soc. of America, annual. (G. F. Papenfuss, Dept. of Botany, Univ. of California, Berkeley 4.)

Sigma Delta Epsilon. (Mrs. C. B. Parker, 7 Lloyd Rd., Malvern, Pa.)

Society for Experimental Biology and Medicine, Pacific Coast Section. (J. P. Baumberger, Dept. of Physiology, Stanford Univ.)

Society of General Physiologists. (D. Mazia, Univ. of California, Berkeley 4.)

Society for Industrial Microbiology, annual. (J. C. Lewis, Agricultural Research Service, USDA, 800 Buchanan St., Albany 10, Calif.)

Society for the Study of Evolution, annual. (R. W. Holm, Dept. of Biological Sciences, Stanford Univ.)

Society of Protozoologists, annual. (J. F. Oliphant, Dept. of Biological Sciences, Stanford Univ.)

Society of Systematic Zoology, Pacific section. (D. P. Abbott, Hopkins Marine Station, Pacific Grove, Calif.)

Western Soc. of Naturalists, annual. (W. M. Hiesey, Carnegie Institution of Washington, Stanford, Calif.)

26-28. Gas Dynamics Symp., 2nd, Evanston, Ill. (A. B. Cambel, Technological Inst., Northwestern Univ., Evanston.)

26-29. Boundary Layer Research, internatl. symp., Freiburg, Breisgau, Germany. (H. Görtler, Mathematisches Institut der Universität, Hebelstrasse 40 Freiburg, Breisgau.)

26-29. Mathematical Assoc. of America, 38th summer, University Park, Pa. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

26-30. American Mathematical Soc., 62nd summer, University Park, Pa. (J. H. Curtiss, AMS, 190 Hope St., Providence 6, R.I.)

26-30. Infrared Spectroscopy Inst., 8th annual, Nashville, Tenn. (N. Fuson, Infrared Spectroscopy Inst., Fisk Univ., Nashville 8.)

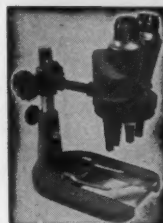
26-31. Low Temperature Physics and Chemistry, 5th internatl. conf., Madison, Wis. (J. R. Dillinger, Dept. of Physics, Univ. of Wisconsin, Madison 6.)

(See issue of 21 June for comprehensive list)

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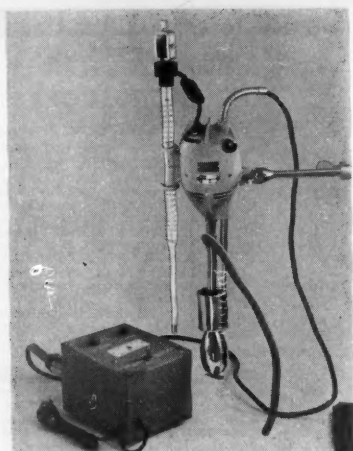
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■ **FORCE TRANSDUCERS** use variable-permeance rectilinear transducers to sense displacements resulting from a force-to-displacement conversion ring. The transducers are said to be less sensitive to temperature changes than are differential transformers or strain gages. The transducer senses either compression or tension without mechanical adjustment. (Crescent Engineering and Research Co., Dept. S422)

■ **CONDUCTIVITY CELL** is designed as a nonclogging tube for measurement of solutions flowing through a liquid system. Electrodes are flush with the bore of the plastic cell. Threaded metal pipe ends permit connection of the cell into the sampling system. A wide range of cell constants, with or without temperature compensation, is available. (Industrial Instruments, Inc., Dept. S255)

■ **SILICONES** and their physiological properties are the subject of a 48-page booklet entitled "Silicones in medicine and surgery." The booklet purports to be the most thorough review of the literature of the subject ever assembled. A variety of aspects of silicones is covered, including dentistry, vial coatings, dermatology, instrument sterilization, and so forth. (Dow Corning Corp., Dept. S416)

■ **ENCLOSED WORK AREAS** are the basis for laboratory design and operation for purity and hazard control. Designed to be universal and flexible, the enclosures have their own air supply and exhaust system with services brought directly through. The enclosures are built up of basic components. A variety of accessories, including remote manipulators, is available. Over-all dimensions of the basic unit are length, 3 ft, height, 2 ft, and depth, 20 or 28 in. (Kewaunee Mfg. Co., Dept. S265)

■ **ELECTRIC INSTRUMENTS** utilize diamond pivots and shock-mounted sapphire jewels to achieve high accuracy with high ruggedness. Instruments incorporating these pivots have accuracies up to  $\pm 0.25$  percent and can withstand the shock of a 3-ft drop to a concrete floor. Friction is reduced so that readings are repeated without hand "tapping" in the most sensitive instrument. No significant wear is reported after 5 million full-scale

deflections. Pivots in existing instruments may be replaced with the new diamond pivots. (Sensitive Research Instrument Corp., Dept. S266)

■ **CAPACITANCE BRIDGE** is designed for measurement of capacitance and dissipation factor at a frequency of 1 Mcy/sec. Measurements over the range between 0.1 and 5 Mcy/sec, can be made with reduced accuracy. At 1 Mcy/sec, capacitance accuracy is  $\pm 0.1$  percent  $\pm 1 \mu\text{f}$ ; dissipation factor accuracy  $\pm 0.0005$  or  $\pm 2$  percent of reading, whichever is larger. When dissipation factor is large, corrections must be made in both measurements. (General Radio Co., Dept. S450)

■ **CULTURE TUBE CLOSURES** of stainless steel, available in six sizes, eliminate use of cotton plugs in growing cultures. Evaporation of medium is reduced by approximately 50 percent. Pressure fingers that grip the outside of the tube prevent accidental removal. (Bellico Glass, Inc., Dept. S448)

■ **DELAY LINE** consists of 120 sections of LC  $m$ -derived networks and a 1-pole, 120-position rotary switch to vary delay. Fourteen models are available with maximum time delays 1.2 to 1200  $\mu\text{sec}$ . Impedance varies from 75 to 1000 ohm. Cutoff frequency in megacycles is 38.4 divided by the total time delay in micro-seconds. (Advance Electronics Lab, Inc., Dept. S449)

■ **QUARTZ-CRYSTAL X-RAY GONIOMETER**, manufactured by Hilger and Watts, Ltd., permits orientation of crystal surface and lattice planes to within 30 sec of arc. A crystal-carrying turret and a Geiger-counter-detector mount rotate independently about a common center. Each carries a precisely divided glass circle. Peak reflections from lattice planes are observed on a rate-of-count meter. Either a high-intensity microfocus x-ray source or conventional x-ray diffraction equipment may be used as source of radiation. (Jarrell-Ash Co., Dept. S451)

■ **LABORATORY SAFETY** is the subject of 56-page booklet. In addition to descriptions of equipment designed for safe handling in the laboratory, the booklet contains sections on accident prevention, first aid, fire prevention, and bibliographic references on laboratory safety. (Fisher Scientific, Dept. S446)

■ **ASPIRATOR**, of explosion-proof design, provides pressure from 0 to 35 lb or vacuum from 0 to 25 in.-Hg. Oil, oil vapor, and moisture are removed by traps. The unit is portable, weighing 35 lb. (American Hospital Supply Corp., Dept. S447)

■ **COMBINATION METER AND AMPLIFIER** covers 15 voltage ranges from 100  $\mu$ v to 1000 v and ten current ranges from 100  $\mu$ ma to 100 ma. The instrument can also be used as a d-c amplifier with up to 80-db gain and high input impedance. Output impedance is less than 2 ohm. Drift after warmup is less than 10  $\mu$ v. Accuracy is  $\pm 3$  percent on all ranges. (Kin Tel, Dept. S441)

■ **ATOMIC FREQUENCY STANDARD**, called the "Atomichron," features a long-time output stability of  $1/10^9$  and provides output frequencies of approximately 5, 10, and 100 Mcy/sec accurate to  $3/10^9$ . The instrument is based on the resonance frequency. Model 1101 lower-accuracy, and lower-priced, version of the previous model 1001 which is stable to  $5/10^{10}$ . (National Co., Inc., Dept. S442)

■ **STABLE PLATFORM** provides a central reference from which heading, roll, and pitch angle information may be obtained. The three-gimbal platform weighs approximately 50 lb and occupies 3.75 ft<sup>3</sup>. The platform is referenced to a magnetic north indicator with provision for free operation during flights in the vicinity of the poles. (Dynamics Corp. of America, Dept. S443)

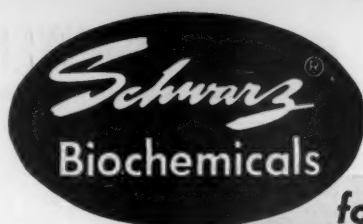
■ **RADIATION ABSORBERS** in a calibrated set of 30 (25 aluminum and 5 lead) provide a means of establishing absorption curves for the purpose of checking radioactivity of an isotope, or to estimate isotopic composition. Each absorber is calibrated to three significant figures, and its mass per unit area is marked. (Technical Associates, Dept. S444)

■ **"RADIO PILL,"** a plastic capsule  $1\frac{1}{8}$  in. long and 0.4 in. diameter, is a frequency-modulated transmitter designed for research in the intestinal tract. The capsule is swallowed and, as it passes through the body, its transistor oscillator transmits a signal that is frequency modulated by pressure. The signals are picked up outside the body and recorded. The position of the pill is traced by fluoroscopy and can be changed by applying magnetic forces from outside the body. Modification for temperature sensing is under development. (Radio Corporation of America, Dept. S437)

■ **ULTRASONIC PROBE** for calibration of ultrasonic equipment has a range of 2 kcy/sec to 2 Mcy/sec. The probe is said to cause only minimum disturbance of the acoustic field being measured. Two models are available, one calibrated at 500 kcy/sec, and the other at five points, 40, 300, 500, 700, and 1000 kcy/sec, to an accuracy of  $\pm 2$  db. (Gulton Industries, Dept. S452)

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National Bureau of Standards

12 JULY 1957



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*Cancer*, Jan-Feb 1956.

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Ph.D. (major, plant pathology; minors, botany, chemistry); 5 years' full-time medical school teaching; 9 years as director, bacteriology departments in research and development, chemical company. Medical Bureau, Burneice Larson, Director, 900 North Michigan Avenue, Chicago. X

Steroid Biochemist, Ph.D.; 10 years of supervisory, research, and teaching experience at well-known institution. Box 216, SCIENCE. X

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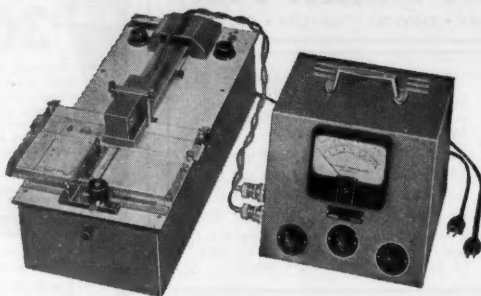
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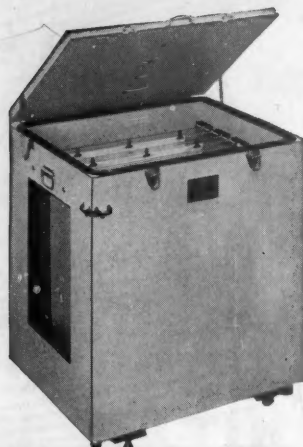


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3673.

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The cabinet frame and cover are 1-inch plywood bonded to white Formica inside and outside to provide adequate insulation under normal conditions. Inside dimensions are 25 3/4 inches long x 19 1/2 inches wide x 27 1/2 inches deep, with double-paned glass window in one end, 17 1/4 inches high x 11 1/2 inches wide. Black phenolic plastic fittings are built in for 4 solvent assemblies which take 8 sheets of suitable paper up to 18 1/4 x 22 1/2 inches. Swivel casters and two handles permit ready positioning, but in use four adjustable leveling feet carry the weight and fix location. Satisfactory working position, with level solvent troughs, is attained by adjusting feet in conjunction with two liquid levels mounted on cabinet.

The cover, sealed by means of a Neoprene gasket, is attached by means of a nickel-plated brass piano hinge with limit chains at both ends to facilitate handling, and has two trunk latches which insure tight closure. Four openings, 1/2-inch diameter, in the cover, fitted with Neoprene stoppers, size No. 00, facilitate replenishment of solvent during a run; a drain pipe in bottom permits flushing as required.

The complement of glassware included with complete cabinets consists of 4 Glass Troughs, 645 mm long x 35 mm wide, with round bottom, capacity approximately 245 ml; 4 Anchor Rods, effective length 590 mm, diameter 8 mm, with bent ends for convenient handling;

8 Anti-Siphon Rods, 650 mm long x 7 mm diameter, with glazed ends; and two Glass Trays, Pyrex brand glass, 18 x 12 x 2 1/2 inches inside depth. Complete cabinets also include a plastic rod to prevent tipping of troughs, 24 Paper Clips of Stainless steel, 6 Neoprene Stoppers, size No. 00, 6 ft. Neoprene tubing, 1/4-inch bore, to drain cabinet, and Pinchcock, 3 1/4 inch size. Height overall, with cover closed, 31 1/4 inches.

**3673. Chromatography Cabinet, Formica, Thomas**, complete with assortment of accessories, as above described, but without paper or siphon for drainage **300.00**

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9186-R2.

**9186-R2. Spray Bottle, Chromatographic (Atomizer), John**, (Patent pending), as above described, with spray tube, screw cap and 8 oz. glass bottle, but without air pump or rubber tubing . . . . . **8.00**

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